HD
9769
.H393
4th
1976

PROCEEDINGS

FOURTH ANNUAL HARDWOOD SYMPOSIUM of the Hardwood Research Council

Managing and Using Our Hardwood Resources

HIGH HAMPTON INN

CASHIERS, NORTH CAROLINA

April 29 - May 1, 1976

TABLE OF CONTENTS

	Page Number	
Board of Directors, Hardwood Research Council	2	
Registration List - Fourth Annual Hardwood Symposium	3	
Symposium Planning Committee	5	
MANAGING AND USING OUR HARDWOOD RESOURCE - Richard L. Greer, Keynote Speaker	6	13232
HARDWOOD MANAGEMENT IS INFLUENCED BY LAND-USE PRESSURES - "Sid" McKnight	10	13233
THE SELECTION SYSTEM OF SILVICULTURE AS A HARDWOOD MANAGEMENT TOOL - Leon S. Minckler	17	13234
COMPOSITION, VOLUME, AND PHYSICAL PROPERTIES OF THE HARDWOOD UNDERSTORY - Douglas R. Phillips and Joe P. McClure	22	13235
PRODUCTION OF QUALITY HARDWOODS BY THE LARGE FOREST INDUSTRIES - Bruce Zobel	31	13236
THE FEASIBILITY OF USING SHORT LENGTH LUMBER IN FURNITURE MANUFACTURE - Samuel A. Bingham	36	13237
FURNITURE PARTS FROM PULPWOOD - A PLANT THAT DID IT - Hugh W. Reynolds	49	13238
A LOW DENSITY FIBERBOARD FROM TOTAL TREE CHIPS FOR THE FURNITURE INDUSTRY - M. W. Kelly and R. G. Pearson	54	13239
NEW METHODS OF DRYING HARDWOOD LUMBER - C. Skaar	68	13240
STRUCTURAL CRITERIA FOR FURNITURE DESIGN - C. A. Eckelman	78	13241
VENEER TIMBER QUALITY SURPLUSES IN THE TENNESSEE VALLEY - Monte R. Harold	91	13242
MODERN METHODS OF PRODUCING FACE VENEER - Thomas F. Hale	102	13243
MARKETING AS RELATED TO IMPORTED AND DOMESTIC HARDWOOD VENEERS - William A. Costoplos	106	13244

* * * * * * * * * * * * * *

MODERATORS

Richard K. Stem, President, Chester B. Stem, Inc., New Albany, Indiana
John Markle, Director Furniture Research & Development Applications Institute, N.C. State University, Raleigh, North Carolina
Robert Hollowell, Jr., Pierson-Hollowell, Inc., Indianapolis, Indiana

HARDWOOD RESEARCH COUNCIL
Board of Directors
May - 1976

Term Expires 1977:

Nick Weidhaas, ROSS ASSOCIATES, INCORPORATED
PO Box 242, Russell, Mass. 01071 Ph: 413-862-3214

H. Brown Kimball, STATESVILLE PLYWOOD & VENEER COMPANY
PO Box 707, Statesville, N.C. 28677 Ph: 704-873-3239 & 704-872-1551

Lee Goble, BROYHILL INDUSTRIES
PO Box 700, Lenoir, N.C. 28645 Ph: 704-758-3000

Term Expires 1978:

Thomas R. Beard, E. N. BEARD HARDWOOD LUMBER, INCORPORATED
PO Box 20188, Greensboro, N.C. 27420 Ph: 919-275-0163 & 919-275-5382

Ames Sexton, BURLINGTON HOUSE FURNITURE--UNITED DIVISION
PO Box 669, Lexington, N.C. 27292 Ph: 704-246-5961

John B. Veach, Jr., BEMIS HARDWOODS--DIVISION OF WHITEWATER, INC.
PO Box 5857, Asheville, N.C. 28803 Ph: 704-254-8164

Term Expires 1979:

Bob Hollowell, PIERSON-HOLLOWELL COMPANY, INCORPORATED
630 College Avenue, N 401, Indianapolis, Indiana 46204 Ph: 317-632-5537

Richard B. Johnston, AMERICAN DREW, INCORPORATED
PO Drawer 458, N.Wilkesboro, N.C. 28659 Ph: 919-838-2121 & 919-838-2349

Rudy Vit, REED LIMITED
PO Box 1487, Quebec City, Quebec, Canada G1K 7H9 Ph: 418-694-7800

APPOINTED MEMBERS - COMMITTEE CHAIRMEN (1 year)

Legislative - E. E. Dargan, ROUNDWOOD CORPORATION OF AMERICA
PO Box 826, Florence, S.C. 29501 Ph: 803-662-8724 & 803-393-1020
Research Priority - W. R. Smith, Rt 4 Box 570, Franklin, N.C. 28734
Ph: 704-524-5056
Extension - Ed Jones, 3028 Biltmore Hall, N.C. State Univ., Raleigh, N.C. 27607
Ph: 919-737-2892 Home: Tarboro, N.C. 919-823-3425
Jim Schroeder, USFS, PO Box 2570, Asheville, N.C. 28802
Ph: 704-258-2850
Symposium Planning - Co-Chairmen:
Stephen G. Boyce, S.E. Forest Exp. Station, PO Box 2570, Asheville, N.C. 28802
Ph: 704-258-2850, Extn. 749
Vincent R. Ross, ROSS ASSOCIATES, INC., PO Box 2018, Asheville, N.C. 28802
Ph: 704-252-6108

Officers:

President - - - - - - - -N. C. Weidhaas Vice President - - -Richard B. Johnston
Secretary-Treasurer - -H. Brown Kimball Council Forester - -Howard J. Doyle
Council Coordinator - - Thomas F. McLintock

REGISTRATION LIST

FOURTH ANNUAL HARDWOOD SYMPOSIUM

High Hampton Inn, Cashiers, N.C.
April 29 - May 1, 1976

(Names printed in capital letters indicate MEMBERS of the HARDWOOD RESEARCH COUNCIL)

Mr. & Mrs. Milton Applefield, USFS, State & Private Forestry, Forestry Sciences Lab., Carlton St., Athens, Georgia 30601.
Mr. & Mrs. RICHARD L. BAGNAL, BAGNAL LUMBER COMPANY, PO Box 5417, Ardmore Station, Winston-Salem, N.C. 27103.
Mrs. Paul Barber, Duxbury, Massachusetts 02332.
Dr. & Mrs. A. C. BAREFOOT, N.C. State University, Raleigh, N.C. 27607.
Mr. & Mrs. W. J. Barker, Rt 63 Box 167, Glenville, N.C. 28736.
Jim L. Barrett, USFS, 1720 Peachtree Road, N.W., Atlanta, Ga. 30301.
Donald E. Beck, SEFES., PO Box 2570, Asheville, N.C. 28802.
SAMUEL A. BINGHAM, ROSS ASSOCIATES, INC., Box 2018, Asheville, N.C. 28802.
JAMES R. BLANEY, BLANEY LUMBER & MFG., Bethesda, Ohio 43719.
LARRY BLOOMER, CRESCENT LAND & TIMBER, PO Box 567, Pickens, S.C. 29671.
STEPHEN G. BOYCE, USFS, PO Box 2570, Asheville, N.C. 28802.
Conrad W. Brewer, Clemson University, Room 272, Clemson, S.C. 29631.
JIM CATHCART, PO Box 6807, Columbia, S.C. 29260.
C. M. Cecil, Drexel Heritage Furnishings, Drexel, N.C. 28619.
JAY CHRISTIANSON, THE BEN MEADOWS CO., 3589 Broad St., Atlanta, Ga. 30301.
Mr. Boyd Close, Buckeye Cellulose Corp., PO Box 208, Perry, Florida 32347.
Steve Conway, Weyerhaeuser Co., New Bern, N.C. 28560.
William A. Costoplos, The Dean Company, Princeton, West Va.24740.
Mr. & Mrs. E. E. DARGAN, ROUNDWOOD CORPORATION, PO Box 13269, Florence, S.C.29501
Mr. & Mrs. Howard Doyle, PO Box 961, Statesville, N.C. 28677.
Mr.& Mrs. Emmett O. Dendy, Pearson Lumber Co., PO Box 1548, Tuscaloosa, Ala.35401
Edward R. Drayton, Sonoco Products Co., PO Box 160, Hartsville, S.C. 29550.
David A. Dubow, USFS, 1720 Peachtree Road NW, Atlanta, Ga. 30301.
William A. Duncan, Appalachia Community Development Corp., Box 432, Appalachia, Virginia 24216.
Carl A. Eckelman, Purdue University, Forestry Dept., West Lafayette, Ind. 47907.
H. S. Friensehner, Florida Div. of Forestry, Collins Bldg., Tallahassee, Fla.32304.
A. B. Glidden III, GMC Hardwoods, Inc., Dover, Mass. 02030.
Mr. & Mrs. Richard L. Greer, Virginia House Furniture, Box 138, Atkins, Va. 24311.
JAMES L. GUNDY, APPALACHIAN HDWD. MFRS. ASSN., Room 408, NCNB Bldg. High Point, N.C. 27260.
Mr. & Mrs. Thomas F. Hale, Wilco Machines, 4096 Viscount, Memphis, Tenn. 38130.
MONTE R. HAROLD, TVA-Div. of Forestry, Fisheries & Wildlife Development, Norris, Tennessee 37828.
R. A. HEIMERS, FURNITURE DESIGN & MFG., 222 S. Riverside Plaza, Suite 2150, Chicago, Illinois 60606.
Lewis E. Herron, Ethan Allen, Inc., Old Fort, N.C. 28762.
Mr. & Mrs. Glenn M. Hinson, Pulaski Furniture, Pulaski, Va. 24301.
Mr. & Mrs. ROBERT E. HOLLOWELL, JR., PIERSON-HOLLOWELL CO., INC. and daughter, 630 N. College Ave., Indianapolis, Indiana 46204.
Mr. & Mrs. J. B. Huffman, University of Florida, 528 NW 36th St., Gainesville, Florida, 32607.
David B. Johnson, USDA-Forest Service, Washington, D.C.
Mr. & Mrs. R. B. JOHNSTON, AMERICAN DREW INC., Box 489, N.Wilkesboro, N.C. 28659.

ED JONES, N. C. Extension Service, 3028 Biltmore Hall, Raleigh, N.C. 27607.
George E. Kelly, Southern Hardwood Lumber Mfrs. Assn., 805 Sterick Bldg., Memphis, Tenn. 38103.
Mr. & Mrs. Howard Kelly, Sr., Timber Glen Forest Products, Abingdon, Va. 24210.
M. W. Kelly, N.C. State University, PO Box 5488, Raleigh, N.C. 27607.
H. BROWN KIMBALL, STATESVILLE PLYWOOD & VENEER, PO Box 707, Statesville, NC 28677.
A. HUGO KIMBALL, STATESVILLE PLYWOOD & VENEER, PO Box 707, Statesville, N.C. 28677.
Jack T. Kirkham, Southern Wood Piedmont Co., PO Box 5447, Spartanburg, S.C. 29301.
Mr. & Mrs. ED KNAPP, ED KNAPP COMPANY, 4435 Pio Nono Ave., Macon, Ga. 31206.
Mr. & Mrs. R. F. KNOTH, R. F. KNOTH & CO., 134 E. Bay, Charleston, S.C. 29401.
Peter Labosky, Clemson University, Room 272, Clemson, S.C. 29631.
John J. Markle, N.C. State University, Raleigh, N.C. 27607.
Mr. & Mrs. "SID" McKNIGHT, Consulting Forester, 656 Tahoe Circle, Stone Mountain, Georgia 30083.
Mr. & Mrs. THOMAS F. McLINTOCK, 75 Cambridge Road, Asheville, N.C. 28804.
RICHARD E. MEADOR, DOLLY MADISON INDUSTRIES, INC., PO Box 129, Huntingburg, Indiana 47542.
BARRY F. MALAC, UNION CAMP CORPORATION, Box 216, Rincon, Georgia 31326.
Ansel E. Miller, Dept. of Forestry, Clemson University, Clemson, S.C. 29631.
Mr. & Mrs. Leon S. Minckler, College of Forestry, Syracuse, N.Y. 13211.
Mr. & Mrs. JOHN E. MOCHA, WESTVACO, PO Box 699, Summerville, S.C. 29483.
Mr. & Mrs. R. A. Moore, S.U.N.Y. College of Forestry, Syracuse, N.Y. 13211.
Mr. & Mrs. Edward L. Odom, Liberty Lumber Co., Box 7, Hosford, Florida 32334.
Mr. & Mrs. DAVID P. OLLIF, CHAMPION INTERNATIONAL, and son, Ken, 809 N. Main St. Rutherfordton, N.C. 28139.
Mr. & Mrs. DAVID F. OLSON, SEFES, & Nancy & Steve, Asheville, N.C. 28802
JIM PARKER, INLAND CONTAINER CORP. PO Box 299, New Johnsonville, Tn. 37134.
JIM PARRISH, BURLINGTON HOUSE FURNITURE, Lexington, N.C. 27292.
Mr. & Mrs. Robert E. Phares, US Forest Service, 12th & Independence Avenue, Washington, D.C. 20250.
Douglas R. Phillips, USDA Forest Service, Athens, Georgia 30601.
Carl F. Pierce, Florida Div. of Forestry, Collins Bldg.,Tallahassee,Fla. 32304.
Philip J. Przestrzelski, Clemson University, Clemson, S.C. 29631.
TERRY REECE, BURLINGTON HOUSE FURNITURE, Lexington, N.C. 27292.
HUGH W. REYNOLDS, NEFES, Princeton, West Virginia 24740.
H. G. Robinson, Van Ply, Inc., Box 8289, Charlotte, N.C. 28208.
Paul H. Rogers, Sonoco Products Co., PO Box 160, Hartsville, S.C. 29550.
Mr. VINCENT R. ROSS, ROSS ASSOCIATES, INC., Asheville, N.C. 28802.
L. M. SCEALS, JR., INLAND CONTAINER CORP., PO Box 299,New Johnsonville,TN.37134.
JAMES G. SCHROEDER, SEFES, PO Box 2570, Asheville, N.C. 28802.
AL SCHULER, NEFES, PO Box 152, Princeton, West Virginia 24740.
Walt Setzer, Drexel Heritage Furnishings, Drexel, N.C. 28619.
ROBERT D. SHIPMAN, School of Forest Resources, Pennsylvania State University, University Park, Pennsylvania 16802.
J. Wayne Short, Soil Conservation Service, PO Box 1002, Sylva, N.C. 28779.
Christen Skaar, VPI & SU, Dept. of Forestry, Blacksburg, Va. 24060.
Mr. & Mrs. WALTON R. SMITH, Rt 4 Box 570, Franklin, N.C. 28734.
Mr. & Mrs. Richard K. Stem, Chester B. Stem, Inc., PO Box 69, New Albany, Indiana 47150.
Mark Swecker, Weyerhaeuser Co., New Bern, N.C. 28560.
Michael A. Taras, USDA Forest Service, Athens, Georgia 30601.
Thomas Tworkoski, Clemson University, Clemson, S.C. 29631.
Mr. & Mrs. JOHN B. VEACH, JR., BEMIS HARDWOODS, DIV. OF WHITEWATER, INC., AND Daughter, Margaret, Box 5857, Asheville, N.C. 28803.

N. C. WEIDHAAS, ROSS ASSOCIATES, Box 242, Russell, Massachusetts 01071.
Robert West, N.B.Dept.Natural Resources, Forest Branch, Centennial Bldg.
Fredericton, New Brunswick, Canada E8B 5H1.
Mr. & Mrs. JERRY G. WILLIAMS, COASTAL LUMBER COMPANY, PO Box 736,
Havana, Florida 32333.
Mr. & Mrs. James Winiarski, Western Carolina University, Cullowhee, N.C. 28723.
Mr. & Mrs. "IKE" YEATER, YEATER LUMBER SALES, PO Box 8111, Akron, Ohio 44320.
Mr. & Mrs. Bruce Zobel, N.C. State University, Raleigh, N.C. 27607.

SYMPOSIUM PLANNING COMMITTEE

Co-Chairmen: Vincent R. Ross, Ross Associates, Inc., Asheville, N.C.
Stephen G. Boyce, S.E. Forest Experiment Station, Asheville, N.C.

Milton Applefield, State & Private Forestry, USFS, Athens, Georgia
Howard Doyle, Council Forester, Statesville, North Carolina
Hugh Reynolds, Forest Products Marketing Lab., Princeton, West Virginia
Frank Shropshire, State & Private Forestry, USFS, Jackson, Mississippi
Walton R. Smith, Forest Products Consultant, Franklin, North Carolina
Nicholas C. Weidhaas, Ross Associates, Inc., Russell, Massachusetts

Family Activities: Mr. & Mrs. W. J. Barker, South Carolina Extension
Forester (Retired), Clemson, South Carolina

MANAGING AND USING OUR HARDWOOD RESOURCE

Richard L. Greer
Vice President and General Manager
Virginia House Furniture Corporation
Atkins, Virginia

The theme of this meeting "Managing and Using our Hardwood Resource" is as timely as the situation is desperate and complex. Consider that in a few years our industry has felt the impact of four actions, any one of which would have posed serious problems.

1. First came the Environmental Protection Agency which required huge expenditures for compliance, ranging from the cleaning up of tree limbs from stream banks to large expensive clean air systems for industry. Many of these requirements were long overdue; however, some were petty. Many existing operations were not efficient enough to warrant immediate improvements as to E.P.A. standards but deadlines were set. Results were predictable; many were ill advised and spent sums of money that did not do the job properly.

If the E.P.A. had allowed old operations a phase out period or had just applied new standards to improvements or new operations, the economical impact would have been easier.

2. Just about the time we were committed to E.P.A. expenditures, the Arab oil producers formed an organization called "Organization of Arab Petroleum Exporting Countries", or OAPEC. OAPEC began by cutting off crude oil supply, reducing production and,in a short time, raising the price of crude oil threefold. Thus ended an era of low priced energy. Electricity advanced 60%, fuel oil price doubled, gasoline prices advanced 50% and any product requiring heat to process went up in price.

3. Shortly after the OAPEC action, the economy of the world skidded and we were in a recession, the worst since the great depression of the 1930's. The forest products industry, which produces hardwood lumber, softwood lumber, plywood, pulp, paper and thousands of related products, hit the lowest production since World War II. In 1975 our industry began to struggle back with less than 1.2 million housing starts. 1974 had 1.3 million starts and 1973 had 2.1 million starts so you can see how much less the demand was for forest products.

The paper and pulp industry had an unusual decline in 1975. Particle board was off 25% in 1974 with little recovery evident in 1975. Appalachian lumber lost 38% of its across the board value by the peak of this downward trend and as of February 1 of this year had regained only 20% of this loss. To make matters worse for the hardwood producers, low grade lumber hardly sold at all. As you might

expect, hundreds of sawmills and related businesses went out of business and many survivors were left in a weakened position.

4. Almost at the same time as the recession came the Monongahela issue, or the ruling by Judge Maxwell on the validity of the 1897 Organic Administrative Act. This ruling applied to the Monongahela National Forest and stated that the Forest Service may not sell any timber from that forest which is not dead, matured or large growth, has not been marked and which would not be removed entirely from the forest after harvesting by the timber purchaser. This ruling was upheld by the Fourth Circuit Court of Appeals so the Department of Agriculture officials stated no more timber would be offered in Virginia, North Carolina, South Carolina and West Virginia, all within the jurisdiction of the Fourth Circuit Court of Appeals.

Like dominoes falling, action has been almost too swift to follow. The Tongass vs. Butts virtually affected ten western states in the jurisdiction of the Ninth Circuit Court of Appeals. There have been appeals to apply to one forest; to apply to all forests; to apply to no forest, and a recent warning that the Fourth Circuit Court of Appeals could rule that the Monongahela decision must be applied nationwide. Should this happen to our 155 National Forests, it is estimated that timber sales would be reduced by 75% the first year and 50% a year for the balance of the century. This translates into a 9 billion board feet loss the first year and a drastic shortage just as business is turning up. In the beginning this will be felt by the forest products industry and finally by the whole nation.

Congress alone can relieve the Monongahela ruling as it is likely all National Forests will be under this ruling in the near future. The whole question is complex and there are those who say the 1897 Organic Act is reasonable. Studies show clear cut to be good, others show clear cut to cause soil nutrients loss. Whatever the solution, try as we might, our industry does not seem to have the power to get Congressional action to date. Maybe it's just election year and after November Congress will face up to the problem.

If all Congress has to offer is Senator Randolph's bill, then we still have the same thing. One thing is almost a certainty; left as is there will be thousands more unemployed, more business failures and another blow to the national economy.

Very recently several pieces of legislation have been introduced in Congress to remedy the confusion and uncertainty.

1. Representative Robert Duncan has introduced 1-1.R.12130 which would amend the 1897 Organic Act to overcome problems created by the Monongahela decision and make clear that the National Forest would be managed in accordance with provisions of the Multiple Use-Substantial Yield Act of 1964 and the Forest and Rangeland Renewable Resources Planning Act of 1974.

2. Senator Humphrey has introduced a bill, 53091, that would require the Secretary of Agriculture to:

a. Prescribe by regulation the environmentally approved forest practices and cutting methods generally available for application in the National Forest;

b. Define forest regions, forest types and forest species;

c. Spell out the practices generally applicable to each region, type and species;

d. Make certain that foresters apply these practices in a manner so that all of the renewable resources would be treated in an ecologically sensible manner and,

e. Establish that forest cutting would proceed only if done in accord with the approved guidelines, with the exception that, for research purposes, the exploration and application of new concepts could be applied on a limited basis.

3. Representative Robert Sikes has introduced IT.R 12232 to establish a Joint Congressional Committee to study existing federal policies and statutes concerning National Forests, and to make recommendations within two years for a definitive national policy in forests.

Some of the above sounds encouraging but let us not forget the people who so fervently oppose any new legislation.

If apathy, the conservationists, the environmentalists and the do-gooders prevail, then the industry will do battle for timber owned by private, state and corporate interests. Let me assure you that if this happens, we will price our product out of the marketplace to the extent that 20% to 40% could be lost to imports.

Management of southern pine forests and corporate western forests have made great strides forward, the reasons being the great demand and the profit motive. I don't believe we can say the same for hardwood forest management, either private or governmental. Private management has been and will continue to be difficult. The payoff is too long ranged to attract owners to invest in good management programs and federal control is still a fighting question.

Not long ago I saw the total acreage of forests in Europe and its percentage of world supply of forest products. It was proportionatly higher than that of the United States. Forest management in Europe is very good but with government control--not yet tolerated in the United States.

It is well known that management as practiced on the federal level lacks purpose and a united policy. How, then, could it be efficient when several agencies, namely the Forest Service, the Secretary of Agriculture, the Office of Management and Budget all have responsibility along with Congress? The need is for a new and intelligent leadership for National Forest policy. This will be a most difficult task with so many special interests. Nonetheless, more production from the National Forests is a must for the nation's needs.

Our National Forest is a great asset that can produce recreation, forest products, wilderness, water and wildlife. I know our foresters have the expertise to do the job given the opportunity, the leadership and new blood.

New medium density fiber board is now on the market. This board will fill, print, and take a profile-shaped edge and look nearly like solid wood. The softwood industry recently announced Plystran, a sheathing with a core of mechanically oriented fiber and Com-Ply studs which sandwich particle board between wood veneers. Hardwood developments along these lines are coming.

New machinery is being developed to give better yields in cuts, rips, and machining. Veneers are being improved yearly with better machinery. New edge banding machines are using thinner veneers and doing a better job. Sanding machines are being developed to do a good job with fewer rejects.

Genetic nurseries are striving for the super tree. Remarkable progress has been made in southern and western softwoods and we have high hopes for hardwoods.

More low grade lumber is being used in furniture and, once promoted to acceptance, even more can be used. The flooring industry can adapt the 8MM parquet flooring and use the lowest hardwood grades.

Residue and offal can be worth $38 to $40 a ton in fuel when produced from plants using 6% mositure content lumber. It is no longer economical to sell this product for $8 to $12 a ton for paper products or chip board. The time is rapidly approaching when it will be economical to use what has historically been left in the forest. I would guess that 20% of the fiber from a tree is still left in the forest.

The Federal Energy Office is thinking of the desirability of a fuel being produced from bark and sawdust for home heating units.

Kiln-drying by fossil fuel is already a casualty of OAPEC whether we are aware of it or not. Oil is costing up to $15 per thousand board feet of lumber to kiln dry from 25% moisture content down to 6%. Natural gas is advancing fast and it is only a matter of time until this cost will be as high as oil.

Kiln-drying in the future will be done at mills. This will allow bark and dust to be burned as fuel. A side benefit from drying at the source will be savings in already expensive transportation. Another kiln-drying source will be at the manufacturing plants near the forests who have an excess of wood residue for fuel.

These challenges will have to be solved successfully for our industry to thrive. If we are to get a fair legislature, every facet of our industry from the timber cruiser to retailer of forest products will have to help. No one part of our industry can sit back hoping the problem will go away because it will not.

Today we are coming out of the economic slump and our keynote is little short of a "hell of a note". If together we can get a fair new law on the use of the National Forests, do a better job of management, utilize our hardwoods more efficiently and continue to innovate, we can have a note of optimism for our industry.

HARDWOOD MANAGEMENT IS INFLUENCED BY LAND-USE PRESSURES

By
J. S. McKnight[1/]

Hardwood supplies for the furniture industry are primarily coming from the Appalachian Mountains and the bottomlands of the South, though a considerable amount of plywood and veneer is imported. The Lake States, Central region and the Northeast furnish volumes of fine hardwoods, particularly maples, beeches, cherry and walnut. I do not believe we need to re-hash the supply situation so well-covered by Dwight Hair of the U.S. Forest Service in our meeting in 1974 (1). What we do need to look at is the availability of this domestic hardwood resource and factors that influence it. "Land-use" has been on the tongues of planners and legislators for a number of years now. Although 1975 saw the defeat of proposed Federal land-use legislation, some states are moving ahead with the setting of policy on how their land shall be used, to protect it from willy-nilly development.

At mid-year in 1975 there was a high level seminar held on the subject, Retention of Prime Lands (2). Concluded was that basic demand for food, fiber and timber products appears certain to increase, causing increased pressure on the use of prime lands suitable to the production of these renewable resources. Factors such as open space, environmental quality and local economic impact will amplify demands on prime land. Thus, it was further concluded, there will need to be actions by local, state and federal agencies to supplement the land market process in allocating land resources among conflicting uses.

Of more importance in the immediate future are legislation, emerging regulations and court decisions that influence forestland management. Just as surely as direct land-use legislation, these indirect actions will influence the use of land. Behind some of these actions are the activities of many environmental organizations and agencies. It is interesting to note that there are 50 federal agencies or groups that can indirectly or directly influence conservation efforts; 332 international, national and interstate organizations involved; and 466 state, territorial agency and citizen conservation organizations active in fields that influence forestry (3). So you see that there are a lot of ladles in the stew.

A dozen federal acts now or will shortly influence land-use in areas of the East where quality hardwoods are growing. These acts are:

(1) 1972 Ammendments to the Federal Water Pollution Control Act, FWPCA for short (PL 92-500)

[1/] Consulting Forester, Stone Mountain, Georgia 30083

(2) Organic Administration Act of 1897 (16 USC 476) as it pertains to the Monongahela issue (Izaak Walton League v. Butz)

(3) 1972 Coastal Zone Management Act, CZM for short (PL 92-583)

(4) Forest and Rangeland Renewable Resources Planning Act of 1974, RPA for short (PL93-378)

(5) Forestry Incentives Program of 1973, FIP for short (part of the Farm Bill PL93-86)

(6) Fish and Wildlife Coordination Act of 1958 (PL85-624)

(7) Eastern Wilderness Act of 1975 (PL93-622)

(8) Wild and Scenic Rivers Act of 1968 (PL90-542)

(9) National Environmental Protection Act of 1969, NEPA for short (PL91-190)

(10) Endangered Species Act of 1973. (PL93-205)

(11) Enabling Act of 1916 (PL39-535 was bill allowing establishment of National Parks and National Preserves) (PL93-439 established Big Thicket National Preserve; PL93-440 established Big Cypress)

(12) Federal Insecticide Fungicide and Rodenticide Act of 1947, FIFRA for short (PL80-104). The Federal Environmental Pesticide Control Act or FIFRA amended of 1972 (PL92-516)

In addition it is well to note that all States in the East have some forms of legislation that directly or indirectly influence the practice of forestry. Some of these include:

(1) Forest practices acts

(2) Land-use acts

(3) Coastal zone management acts

(4) Environmental protection acts

(5) Water acts and sediment control acts

(6) Multi-county planning district laws

(7) Tax laws

I list the above to document important laws and to impress you with the number of laws. There are more! Perhaps the modern attention is due to a number of reasons but certainly a growing population combined with more time and money for recreation have a major influence in the amount of conservation legislation already written. We can expect more.

Competing uses for land have been with us for some time and will continue.

Farmers have always yearned to plant on the rich, moist soils of the bottomlands from which volumes of quality hardwoods have come in the past and from which a goodly supply is still obtained. These we are losing to the inroads of advanced cultivation techniques but encouraged by massive drainage and flood protection programs. Of course the prime example is the reduction of the acreage of hardwood forest in the lower valley of the Mississippi River in the last three decades. Exploration of this use discloses another big demand on lowland hardwood sites --- reservoirs and other major natural waterway alterations. Some of the finest hardwood sites have been buried under water in such projects along most of the major rivers of the South. And where they are not lost thusly they are sometimes confiscated under legislation which allows single use, even of prime forestland.

A subtle whittling away occurs throughout the East as forested acres are needed or, at least, used for housing developments, as communities or as service areas such as highways and utility rights-of-way. Of course there is some reversion of open land to forest, but little of this new forest is on high quality hardwood sites.

I have purposely taken you on this expedition through the maze that seems to mostly reduce the land base for hardwood production. However, it is not my purpose to discourage anyone from believing in the need for hardwood forest management in the future. Rather we need to reason together about what the effects of all these factors may be and chart a course that will assure that quality hardwoods (not just cubic volume of hardwoods) will be available for the industry requiring such raw material.

Uplands and bottomlands will be affected by a few of the same land-use pressures. These basic land resource areas differ in the main and can best be discussed separately. Of course we need to recognize that there are "gray zones" where the uplands join the lowlands. Since I think we all believe the pressures for other use will increase rather than subside let's look at some of the immediate tangible pressures and then draw some conclusions.

Uplands

Probably the most immediate problem in the eastern mountains concerns management of National Forest lands. Stemming from the law-suit brought by the Izaak Walton League against Earl Butz as Secretary of Agriculture, currently the Forests are dribbling out about 10 percent of their planned cuts of timber in West Virginia, Virginia, North Carolina and South Carolina. In addition the court decision has been extended to halt cutting in Alaska of all but dead, dying and physiologically mature timber. Actions are underway in the Congress to review the situation brought on by the court decision on the old act and possibly provide corrective legislation. There is no question in my mind that such legislation should clearly spell out policy that the U.S. Forest Service must follow for the greatest good of the people. Then the Forest Service will need to apply, under the Multiple-Use concept, the very best practices to meet all national demands, insofar as practicable.

Under the year-old Eastern Wilderness Act there will be further limitations placed on Federal lands. Some private lands will also be purchased or donated under this act. Such actions will remove hardwood acreage from timber production. How

much land will be affected is not known. In addition, there will be more recreation areas in the Appalachians where urbanites are spending more and more time and money pursuing the good things of life. Wild and Scenic Rivers, such as the Chatooga in Georgia, will be set aside for single use and to help satisfy this demand for the enjoyment of leisure time.

The Federal Water Pollution Control Act and its 1972 ammendments is a big Bill and will influence how timber is cut throughout mountain watersheds and most other uplands, particularly insofar as access roads, logging methods and planting procedures are concerned. Reasonable care will have to be applied to avoid sediment in streams. In addition, selection cutting will probably become the rule on all lands along main fishing streams to avoid loss of shade and resulting increased water temperatures brought on by clearcutting. Areas of high visibility to visitors will also require careful application of silviculture, sometimes at the expense of maximum production and ease of management control.

In my opinion, all interests in appropriate land-use should aim for the major reserved areas to be on sites where trees, or other important crops for that matter, do not grow well commercially. Much of the Blue Ridge Parkway, by sticking to the ridges, traverses relatively poor sites.

Terrain less rugged than mountains, such as the Piedmont and hill-and-hollow parts of the Coastal Plain, will require more common-sense attention to certain aspects of applying forest practices. This will not only be required by the FWPCA but it is only good business to save the soil that produces the raw material important for wood-using industries. Probably the access part of the operation, as in other landforms, can cause a high percentage of the environmental damage. Roads have to be well laid out to avoid erosion and subsequent stream pollution. Logging will be done to minimize the type land scars that cause washing of the soil and sedimentation of water courses.

My work over the past 30 years has taken me over all of the southern and eastern regions of this country. Observations and conferences with researchers and operations managers has led me to the rather firm opinion that relatively minor streams in most uplands might best be managed for the production of hardwoods. Such management would be primarily of natural stands and would consist of judicious use of a modified selection system. Examples of application that look practical to me are being tried where the majority of the ownerships are under intensive pine plantation management. Stream borders, sometimes several hundred yards wide and miles long, are initially logged for improvement and to remove large trees. Stand openings are completed during the harvest by deadening weed species and culls. This practice reduces the age and average size of the residual stand to a point where any further cutting will be done in concert with cutting cycles of adjoining plantations.

There are several advantages to this system of management. Foremost, it puts the right species on the right sites and can produce quality hardwoods. Such areas are useful for wildlife food and the habitat of some birds and animals. Water quality can be controlled better with such strips when logging is done carefully. Finally, it eases the burdens of the landowner and operator in meeting water quality requirements either now or not later than 1978 when the FWPCA requires best management practices.

Bottomlands

The lands adjoining major streams and Rivers have the greatest pressure for use on them, yet produce quality hardwoods fast. That is, if the forest is not replaced by pasture, row crop or water. Laws that have provided for channeling these bottomlands, avoiding floods in them and provided navigation advantages such as locks and dams, and the making of reservoirs for recreation and power are the main forces reducing the forest. Economic forces naturally come into play, too. However, appropriate land use should dictate that some bottom-lands will remain in hardwood forest.

One of my favorite gripes is the clearing for soybeans and other crops some of the land between the levees of the Mississippi River and its tributaries where they are protected by levees. During floods, the fields with no cover and no binding root systems tend to become man-made "sandbars", shifting and sliding downstream. This is costly for the taxpayer who must bear the burden of revetments and dredging for navigation.

Two bits of legislation can threaten a relative small amount of the best forest land in river bottoms. One is the Fish and Wildlife Coordination Act of 1958 which allows the purchase of private lands in mitigation for projects of the U.S. Army Corps of Engineers wherein wildlife habitat is destroyed. These lands can be taken through the right of eminent domain and are usually placed in the hands of a state wildlife agency to manage. Another threat to a relatively small amount of good timber is the federal act allowing the taking of private land and placing it in a preserve status under the Park Service. The Congaree River bottom is a case in point. These environmental groups first sought 70,000 acres as a National Park or Preserve. Now they seek the 15,000-acre Beidler tract containing much old-growth hardwood and swamp tupelo and cypress land containing some of the richest soils in the nation.

As spokesmen for economic as well as environmental interests point out, these are only a few thousand acres in millions. But, in miniature, the situation helps us to visualize the land-use situation when it is handled by bits and pieces. Another case in point was the channeling and draining of wet lands fostered by the Soil Conservation Service more in the late forties, fifties and sixties than in recent years. Drainage ditches were dug to relieve farms of water build-up in wet periods. These ditches, however, traversed in many cases great distances before being emptied into natural major drainages. Of course, such ditches encouraged land-clearing along the way. The Corps of Engineers provided improved drainage on major streams with the concurrence of local government.

This sort of activity, as much as the mainline levees, caused land speculation and clearing on sites that were marginally suited for farming even with the artificial drainage. Pile up of water from this activity is exemplified in the lower reaches of the White River where it surges to move with the Arkansas River into the Mississippi. But to no avail. Giant areas are now inundated on the Lower White River almost every year. Former stands of hardwood timber are fast succumbing to the pile up of water trying to get into the Mississippi when it, too, is flowing high from increased drainage. And the water flows muddy as always but even more so because of the rush of muddied water from bare fields from straight dug channels into the natural streams.

Logging in very wet weather can churn the mud of bottomlands, then that mud can make turbid the waters into which it is washed by winter rains. However, all of this is gradually being brought under control by the coastal zone management acts of some states and being encouraged in others by the federal CZM. The FWPCA seeks through Section 208 to reduce non-point source pollution from whatever source be it forest or field and point source pollution through Section 402 and 404. The U. S. Army Corps of Engineers has primary authority for handling section 404 which includes the dredge and fill requirements aimed at reducing pollution from discrete sources where earth is moved in a watershed. By 1978 this authority will be extended to the headwaters of even small streams.

Positive Aspects

Whatever the site, there are some very positive aspects about the availability and future growth of quality hardwoods. First, the federal Forestry Incentives Program recognizes the need for stand improvement in hardwood stands where sawtimber is the goal. There should be more attention to this approach on the non-industrial private ownership. On other ownerships, immature stands should be thinned or cleaned to nurture the quality trees. Not enough of this intermediate treatment is apparent with one of the reasons being the preoccupation of foresters with regeneration instead of the final product.

The Environmental Protection Agency is charged with achieving the goals of NPS pollution abatement through the States. This is a good approach in itself. More importantly, however, it has decided to achieve the goal through the encouragement of Best Management Practices (BMP). This approach does encourage us to approach improved water quality in forests through the forest practices route. In my mind this means that foresters, water quality control officials, scientists and forestland managers can develop guides for the application of forest practices. These guidelines, while being based on our best knowledge of the total biology of the forest and its waters, will direct the practitioner on the basis of his woods operations. Liability will not at any point in time be the quality of the water resulting but how well the owner or operator adhered to the rules agreed upon periodically as the basis of BMP.

I would be badly remiss if I did not recognize the improvement in the quality and style of State Forestry in most eastern states. Virginia is an excellent example where more and more recognition is being provided by the legislature to the importance of improved forestland management as a basic element of the economy and environment of the State. The State's Reforestation of Timberlands Act recognizes the importance of incentives to promote better forestry among non-industry landowners. Hardwood specialists have been assigned to work with landowners in a number of States. The Sawmill Improvement Program, being jointly done by the U.S. Forest Service and State personnel, is extended to hardwood as well as pine mills. Research is doing a greatly improved job of getting out sound advice to practicing foresters.

Finally, there is still a great deal of activity on the federal stage and in the States toward enacting land-use legislation that will void the waste of the productivity of some of our prime lands. Although such legislation has not passed at the national level, Florida, North Carolina, Maryland, Vermont, Maine, Minnesota, Colorado, Hawaii, Oregon, Nevada, and Utah already have laws that guide appropriate land use. Foresters, wood-using industry managers, and landowners must stay up-to-

date on legislative activity in this field to help guide any laws toward real practicability.

Summary

Other economic land-uses have reduced bottomland acreages on which quality hardwoods forests once grew. Uplands are influenced more by the demand for increased outdoor recreation including wilderness areas, biological preserves, aesthetically pleasing scenes, second homes and expanding population. Legislation is involved in changes being wrought on both general land forms. Public agencies and hundreds of private or semi-private organizations sway legislation and public opinion in the field of conservation.

Legislation of the last several years that influences forestry most is concerned with maintenance of water quality. Court action has had direct effect on the cutting policy of National Forests in the east. All of this activity will cause some direct action to firm up policy on forest management. However, land-use legislation is still coming over the horizon. Those interested in assuring that land-use for managed forests has its proper place in the scheme of things must be actively concerned.

In conclusion, it may be well to note that one federal law may be the basis for major national policies about the use and management of forests. The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) is receiving considerable attention by Congressional committees at this time. If Congress in its wisdom, seizes the opportunity this may be the vehicle to set firm and good policies for the future course of all forestry, including that which will continue to yield quality hardwoods.

Literature Cited

(1) Hair, Dwight. Foreign trade in hardwood timber. Proc. Second Ann. Hdwd Sympos. of the Hardwood Research Council. Statesville, N.C. 1974.

(2) U.S. Department of Agriculture. Perspectives on prime land. Proc. prime land use seminar. 275 pp. 1975. (single prints available from Soil Conservation Service, Wash., D.C. 20250)

(3) National Wildlife Federation. Conservation Directory 21st ed. 235 pp. National Wildlife Fed., Wash., D.C. 1976.

THE SELECTION SYSTEM OF SILVICULTURE AS A HARDWOOD MANAGEMENT TOOL

Leon S. Minckler[1/]

Silviculture is the art of forest culture based on the biological and physical sciences for the material, social, and spiritual welfare of mankind. A silvicultural system is a method of regeneration of new stands together with all the cutting methods, treatments, and controls required during the management period. The selection system involves the emulation of nature but usually on a different time scale. Cultural measures are taken before similar events would normally occur in nature, thus avoiding waste, increasing net yields of wood, shortening rotations, and attaining a greater flexibility in the character of the standing forest to enhance both timber and non-timber values. This is an important part of forestry. I like to think that forestry should "promote the integrity of the working forest ecosystem". Thus many values are obtained from the forest without loss of productivity or the basic character of the ecosystem.

There are several positive principles in managing natural forests that should always be remembered. The managed forest must be considered as an ecosystem where all parts are interrelated, recognizing that no action can be taken without affecting the whole. We must also recognize the ecological imperatives and requirements of the forest and its components and work within these limits. Another positive principle is that we can have integrated multiple values in forest management and this also involves maintaining the productivity of the forest sites. This is a moral responsibility to future generations. It is possible and feasible to have sustained yield of timber and other forest values on the same area.

The job of good forestry is not completed until the logs are delivered to the mill. The job of the silviculturist is not done until the logging trucks are out of the woods. His job includes not just the marking of trees and the regulation of the forest but also minimizing or eliminating the impact of timber harvesting and removal on the forest environment.

Silvicultural Systems

The prescription of a silvicultural system should be based on the following criteria: (1) species requirements for regeneration, (2) forest structure and tree age arrangement, (3) condition of trees in the management unit, (4) site quality and diversity, (5) socio-economic value equation, (6) environmental protection, and (7) objectives of management. The first four are biological or silvicultural in nature and the last three are concerned with values and objectives, both long

---

1/ Adjunct Professor, College of Environmental Science and Forestry, Syracuse, New York. Presented at Fourth Annual Symposium of Hardwood Research Council, Cashiers, N. C. May 1, 1976.

and short term and both timber and non-timber. Generally, it is better to determine the systems which are biologically viable and then decide which system or combination of systems will best fulfill the commodity, social, and environmental values desired.

Example of Selection Silviculture

Let's assume a sizeable hardwood forest of several hundred acres typical of the southern Appalachians or southern Central States. Sites are average or better but highly diversified because of topography and soil types. The forest was cut 50-60 years earlier for the largest and best trees, with all small trees, low quality trees, and culls left. The diameter distribution is J-shaped, that is, ranging from many pole-sized trees per acre to fewer and fewer as the size class increases. Tree condition and quality for sawlogs ranges from excellent to poor to worthless culls. Species composition is mixed including red oaks, white oak, yellow poplar, hickory, ash, black cherry, and sugar maple at the higher elevations. Let's further assume that the owner's objectives are high quality sawlogs and veneer logs plus some concern for a pleasant, and diversified forest, site protection to assure high water quality, and a reasonable continuous yield of high quality timber in the future. How should a forester go about accomplishing these objectives on this rather common type of forest?

The overall game plan would be to make a combined improvement and regeneration cut and treatment. The improvement cut (an intermediate cut) is designed to cut or kill the cull trees and cut the poor merchantable trees not wanted as growing stock. This is for the prupose of providing more growing space for good trees and, in conjunction with regeneration cuts, help provide space for regeneration to develop. The regeneration cut harvests mature trees. It is the end of the rotation for those trees and cutting provides space and light for regeneration. In our example group selection should be used and openings about one-eighth to one-half acre made because this is necessary for the light requirements of these species.

Notice that the good growing stock trees are left to grow. Most already have an investment of 30 to 70 years and they will quickly grow into mature sizes of high quality trees. These treatments commonly leave a mosaic arrangement of large and small trees and of cleared regeneration areas. (In some cases so few good trees remain that whole patches of several acres should be clearcut). So what has been accomplished? The mature and poor trees have been harvested and the cull trees have been killed or perhaps cut for pulp or firewood. This provides more growing space for the good growing stock trees and, when trees are harvested or killed in groups, provides space for new regeneration. The forest has been rehabilitated and new seedlings and saplings can develop unhindered.

Tree Classes

Indispensible to the application of such a combined regeneration and improvement cut is a knowledge of tree classes based on their present value and future possibilities. These classes, and their application in silviculture, have been described in detail in my book Woodland Ecology (Syracuse University Press, 1975). The tree classes have descriptive names as follows: (1) good growers, (2) mature crop trees, (3) sound, low-quality trees, (4) high-risk trees, and (5) cull trees. In addition, some owners may wish to designate wildlife and aesthetic trees. Good growers are trees that should be left to grow to rotation size. Mature trees have reached economic maturity for sawlogs or veneer. Sound, low-quality trees will live for many years but will have a low future value growth. High risk trees will usually be lost before the next cutting cycle. Cull trees are not now merchantable except for firewood and have no potential merchantability.

For timber purposes in a combined improvement and regeneration cut the good growers would be left and perhaps some of the mature and the sound low-quality trees. (Depending on markets, stocking, volume, size of openings, etc.) All the high-risk trees and most of the mature and sound low-quality trees would be harvested. Unless left for wildlife purposes, all the cull trees would be killed. This is not complicated. A forester soon learns to recognize these trees at a glance as well as how and when to make openings for regeneration. Silviculture is an art based on science and this is the practice of the art.

Stand inventories are required at each cutting cycle (10 to 15 years) to determine the cut and to regulate both the volume and diameter distribution for a reasonable sustained yield. This is entirely feasible and practical. Inventories should include species or species groups, diameter classes, and tree classes. To compute volumes an estimate of merchantable heights will also be required. On small woodlands a 100 percent inventory of pole and sawtimber sizes is usually required but trees can be easily "eye-balled" into 3-inch diameter classes. On large management units some system of sampling will usually be required. An experienced forester can do a good job of regulation for reasonable sustained yield with a minimum of detailed physical data and computations.

Results of Group Selection Silviculture

In the slides I will show you will see how forests look 20-25 years after combined improvement and group selection cutting treatments to improve the quality of the stands and create openings for regeneration. (This work was done on the Kaskaskia Experimental Forest in southern Illinois.) The openings have filled with saplings and small poles, the former poles have grown into small and medium sawtimber, and the former sub-mature sawtimber have become economically mature. A brief summary of the sawtimber volumes before and after a 16-year treatment period is shown in the following tabulation. All volumes are board feet International scale per acre. (Data adapted from Richard C. Schlesinger, "Some changes after 16 years in managed, uneven-aged, upland hardwood stands in southern Illinois". File report, U.S. Forest Service Carbondale, Ill.)

	Original volume	Cut volume[1/]	Residual volume after 16 years	Annual net growth
Mixed hardwoods. 197 acres in 10 compartments cut an average of 3.5 times.	4731	2951	5840	254
Oak hickory. 233 acres in 11 compartments cut an average of 2 times	2688	1534	3796	165

1/ In addition to the volume shown the tree removal included 60 cull trees per acre of all sizes above 4.6 inches in diameter which were killed.

The original diameter distribution tended to be J-shaped but there was a poor representation of trees below 5 inches in diameter and most of these were overtopped. After the 16-year management period the number of saplings free to grow had increased many fold, trees 5 to 12 inches had decreased moderately, and trees 14 to 24 inches had increased slightly even though many had been cut. The pole "good growers" had grown into sawtimber sizes and openings had filled with sapling reproduction, as shown in slides.

Another example of response to combined improvement and group selection was shown by what was called the "poor farm woodland" on the Kaskaskia. This was a 21-acre degraded forest with many non-growing stock trees but with a good stocking of 1 to 4-inch saplings which had developed after previous cuts. The number of live trees per acre by size classes is shown in the following tabulation:

Diameter class; dbh inches	Original woodland 1952	Trees cut and killed 1952, 1959	Woodland 1967
5- 7	43	51	54
8-10	20	11	18
11-17	30	14	22
18+	3	4	4
Totals	96[1/]	80	98[2/]

1/ 32 of these trees were culls of all sizes.

2/ 13 of these were small pole culls.

The original sawtimber volume in 1952 was 3029 bd.ft. per acre, 1759 was removed in two cuts plus more than 60 cull trees, and in 1967 the volume was 3189 bd. ft. In addition there were 59 growing stock pole trees per acre plus a dense stocking of saplings 1 to 4 inches in the openings. In the first 15 years of rehabilitation treatments this poor woodland made a net growth of 128 bd.ft. per acre annually, the number of good growers increased greatly, and most culls have been eliminated. Species composition was about the same except there was an increase in white oak and yellow-poplar and a decrease in hickory and black gum.

Wood Quality

For most uses fine hardwood trees should have moderately fast but a fairly even growth rate. Growth rings should not vary widely from section to section of the log. In group selection silviculture seedlings, saplings, and larger trees are at no time overtopped. They are always free to grow. As compared to clearcutting, however, tree growth would be somewhat slower through the pole stages but about the same during sawtimber stages. Thus, when properly applied, group selection could result in more even ring widths than in even-aged hardwood forests. But even more important, trees harvested by the group selection system are, on the average, much larger than trees from clearcut areas. As is well known, larger trees have quality superior to small sawtimber trees.

Conclusion

What we should do then in these typical eastern mixed hardwood forests is harvest the mature and other merchantable non-growing stock trees, kill the cull trees, and provide openings for new regeneration. The pole-sized and pre-mature high quality timber trees left to grow will quickly provide good sawlogs for future

harvest. With 40 to 70 years already invested in these good growers the production of quality timber becomes feasible in the short run and can continue indefinitely at the rate of 200-300 bd. ft. per acre annually. Clearcutting such stands requires the utilization of many more smaller and low quality trees as well as sacrificing the many years required to grow a tree to the size needed before quality wood can be added. To equal the approximate volume growth of selection forests a stand after clearcutting with a 100-year rotation (necessary for high quality logs) would have to contain 15,000 bd.ft. per acre plus a yield of 10,000 bd.ft. in intermediate cuttings. I have not seen this except on bottomland and the best cove sites. If we want large, high quality logs we had better let grow the pre-mature "good growers" we already have. Quoting from Woodland Ecology, "In growing from sixteen to twenty-two inches in diameter during the next thirty to sixty year period a tree will nearly triple in sawlog volume and easily increase five times in value". Cutting immature good growing stock is poor timber economics, and it is not necessary silviculturally.

COMPOSITION, VOLUME, AND PHYSICAL PROPERTIES OF THE HARDWOOD UNDERSTORY

by

Douglas R. Phillips and Joe P. McClure[1/]

Abstract. *Understories of mature hardwood stands contain many species, but most of the volume is concentrated in 6 to 10 of these. We examined six understory hardwood species (yellow-poplar, red maple, white oak, red oak, dogwood, and hickory) at two locations to determine volume yields and tree physical properties. Average aboveground volumes of total trees, including crown, ranged from 1.0 to 1.4 cubic feet. Green and dry weight per cubic foot values were about the same as those reported for dominant and codominant trees. Bark yield of understory trees ranged from 15 to 17 percent of dry weight in dogwood to 27 to 29 percent in hickory.*

Additional keywords: *understory hardwoods, cubic volume, green and dry weight per cubic foot, bark percentage, Liriodendron tulipifera, Acer rubrum, Quercus alba, Q. prinus, Q. falcata, Cornus florida, Carya Spp.*

Understory hardwoods less than 5 inches d.b.h. are ignored in most timber inventories and are often overlooked as a potential source of wood fiber. This practice may well change in future years as our resources dwindle and as total tree chipping gains acceptance.

Only limited research has been conducted on small hardwoods. Sollins and Anderson (1971) compiled dry weight data for a wide range of species of different sizes, and Barker (1974) examined the papermaking properties of 5- to 9-inch d.b.h. hardwoods. But data on suppressed understory trees less than 5 inches d.b.h. are not readily available. In the study described here, we examined the composition, volume, and physical properties of the hardwood understory in two geographic regions of the southeastern United States.

METHODS

Stand Composition. Our first objective was to determine which species occur most frequently in the understories of hardwood stands. We decided to examine two geographic regions: the mountains of North Carolina (Figure 1) and the Piedmont of Georgia (Figure 2).

[1/] Associate Mensurationist, USDA Southeast. For. Exp. Stn., Forestry Sci. Lab, Athens, GA 30602 and Primary Resource Analyst, USDA Southeast. For. Exp. Stn., Asheville, NC 28802, respectively.

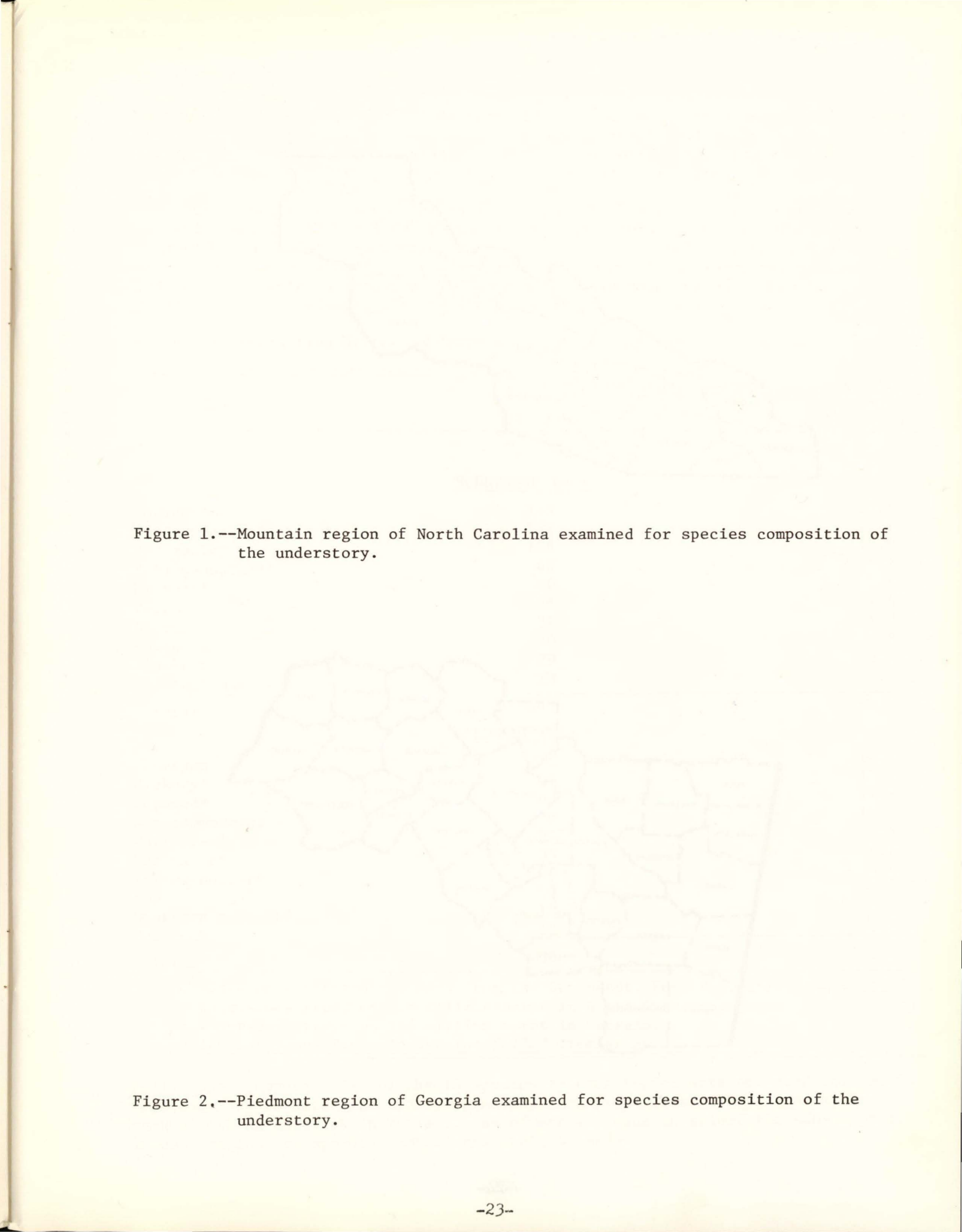


Figure 1.--Mountain region of North Carolina examined for species composition of the understory.

Figure 2.--Piedmont region of Georgia examined for species composition of the understory.

ASHE
ALLEGHANY
WATAUGA
WILKES
AVERY
MITCHELL
YANCEY
CALDWELL
MADISON
BURKE
McDOWELL
BUNCOMBE
HAYWOOD
SWAIN
JACKSON
HENDERSON
GRAHAM
TRANSYLVANIA
MACON
CHEROKEE
CLAY

HALL
BANKS
FRANKLIN
HART
FORSYTH
JACKSON
MADISON
ELBERT
POLK
GWINNETT
BARROW
CLARKE
OGLETHORPE
PAULDING
COBB
OCONEE
HARALSON
FULTON
DE KALB
WALTON
ROCKDALE
DOUGLAS
CLAYTON
CARROLL
NEWTON
FAYETTE
HENRY
COWETA
HEARD
SPALDING
TROUP
MERIWETHER

The mountain region contains approximately 3.2 million acres of commercial forest land which is predominately hardwood (Cost 1974). Approximately 1.9 million acres of this land supports merchantable hardwoods that could have some understory trees. In the Piedmont, 1.1 million acres are classified as hardwood (Knight 1972), with just under 1.0 million acres that could contain some understory hardwoods.

During the Forest Survey of these regions, the above acreages were examined to see which species occurred in the understory and in what quantity. The 10 most commonly found understory species in each region are listed in Table 1. With few exceptions, the understories are very similar. Dogwood, hickory, red maple, white oak, and yellow-poplar occurred in large numbers in both regions. Sweetgum was dominant in the Piedmont, but did not occur in the mountains.

Table 1.--Composition of the understory in mature hardwood stands at two locations[1/]

Species	Ten most predominant species 1-5 inches d.b.h. Number of stems	Percent of all species
	Millions	
	MOUNTAINS (NC)[2/]	
Dogwood*	174	23.1
Non-commercial	121	16.1
Red maple*	106	14.0
Yellow-poplar*	48	6.4
Hickory*	40	5.4
Beech	35	4.6
Birch	32	4.3
White oak*	30	4.0
Blackgum	29	3.9
Chestnut oak*	28	3.7
Total	643	85.5
	PIEDMONT (GA)[3/]	
Sweetgum	75	14.1
Hickory*	64	12.1
Dogwood*	62	11.8
Non-commercial	56	10.5
White oak*	37	6.9
Red maple*	35	6.6
Yellow-poplar*	23	4.4
Ash	20	3.8
Southern red oak*	19	3.5
Post oak	15	2.9
Total	406	76.6

[1/] Based on Forest Survey data from the Southeast. For. Exp. Stn., Asheville, NC.
[2/] Understory trees on 1.9 million acres in North Carolina.
[3/] Understory trees on 1.0 million acres in Georgia.
* Indicates species selected for felled tree study.

Felled Tree Samples. Six of the 10 species in each region were selected for felled tree sampling to determine tree volumes and wood properties. These species are marked with an asterisk in Table 1. An effort was made to select the same species in each region, so species comparisons could be made.

A total of 72 trees (6 species x 12 trees) were harvested at each of two locations--the Bent Creek Experimental Forest in the mountains of North Carolina and the Scull Shoals Experiment Forest in the northern Piedmont of Georgia. Three trees in each of four diameter classes (1.0-1.9, 2.0-2.9, 3.0-3.9, and 4.0-4.9 inches d.b.h.) were chosen for each species. Means and ranges of sample tree characteristics are given in Table 2.

Table 2.--Physical characteristics of understory trees sampled at two locations

Species	Sample trees	D.b.h.		Total height		Age	
		Mean	Range	Mean	Range	Mean	Range
	No.	- - In. - -		- - Ft. - -		- -Yrs.- -	
		MOUNTAINS (NC)					
Yellow-poplar	12	2.9	1.5-4.7	35	23-49	18	14-23
Red maple	12	2.9	1.2-4.5	36	19-50	34	12-70
White oak	12	3.0	1.3-4.9	28	14-45	44	20-60
Chestnut oak	11	2.9	1.5-4.7	35	19-51	25	12-56
Dogwood	12	2.8	1.0-4.8	23	15-33	44	17-75
Hickory	12	3.0	1.2-4.6	33	19-47	42	22-57
		PIEDMONT (GA)					
Yellow-poplar	12	3.0	1.2-4.7	32	18-45	19	6-28
Red maple	12	3.0	1.7-4.5	34	25-44	37	34-45
White oak	12	2.9	1.2-4.9	28	15-44	33	18-55
Southern red oak	13	3.1	1.5-4.6	33	17-49	33	25-53
Dogwood	12	3.0	1.4-4.7	27	16-35	36	20-55
Hickory	11	2.9	1.0-4.5	30	16-44	36	20-56

In the winter of 1975, the trees at both locations were cut, weighed, and measured. Trees were felled, separated into stem and branch components, and weighed. Stem length was measured to the nearest half foot and diameter measurements were made at the stump. Sample disks were cut from the stem at a 1-foot stump, at d.b.h. (4-1/2 feet), and at 25, 50, 75, and 100 percent of total height.

Samples were also cut from the branches. Three branches were selected at random from alternating sides of the crown beginning at the base and working towards the top. Three 2-inch sections were then cut from the base, middle, and top of each branch, giving us a total of nine samples from each crown.

In the laboratory, stem and crown samples were measured for green weight, green volume, and ovendry weight. All measurements were made with bark intact. Green volume was determined by water displacement and ovendry weight was determined after samples were dried to a constant weight at 103°C. Bark was removed from samples and wood alone was ovendried at 103°C, so we could compute bark percentage on a dry weight basis.

Moisture content and specific gravity values were used to determine green and dry weights per cubic foot. Cubic volumes were computed by dividing green weight by green weight per cubic foot. Stem, branch, and tree properties were calculated by weighting sample values in proportion to the volume each sample represented.

RESULTS

Cubic Volume.--Average stem cubic volume with bark of understory trees ranged from 0.74 to 1.13 cubic feet and made up 67 to 88 percent of the volume in the total tree aboveground (Table 3). Branches contained an average of 0.13 to 0.43 cubic feet and represented 12 to 33 percent of the volume in the total tree. Dogwood was by far the most prolific brancher with about one-third of its total weight in branches. White oak had the smallest crowns with only 12 to 13 percent of tree volume represented by branches.

Table 3.--Cubic volume of understory trees by region and species

Species	Sample trees	Sample average		Average cubic volume		
		D.b.h.	Total height	Stem	Crown	Tree
	No.	In.	Ft.	- - - - - Cu. ft. (%) - - - - -		
MOUNTAINS (NC)						
Yellow-poplar	12	2.9	35	1.08 (88)	0.14 (12)	1.22
Red maple	12	2.9	36	1.13 (81)	0.27 (19)	1.40
White oak	12	3.0	28	1.01 (88)	0.14 (12)	1.15
Chestnut oak	11	2.9	35	1.11 (88)	0.15 (12)	1.26
Dogwood	12	2.8	23	0.74 (67)	0.36 (33)	1.10
Hickory	12	3.0	33	1.03 (86)	0.16 (14)	1.19
PIEDMONT (GA)						
Yellow-poplar	12	3.0	32	1.10 (81)	0.26 (19)	1.36
Red maple	12	3.0	34	0.94 (69)	0.43 (31)	1.37
White oak	12	2.9	28	0.90 (87)	0.13 (13)	1.03
Southern red oak	13	3.1	33	1.13 (87)	0.17 (13)	1.30
Dogwood	12	3.0	27	0.91 (71)	0.37 (29)	1.28
Hickory	11	2.9	30	0.93 (76)	0.30 (24)	1.23

Total tree cubic volume averaged from 1.03 to 1.40 cubic feet (Table 3). Volumes of this magnitude may seem insignificant on an individual tree basis, but when hundreds of stems occur on a given acre they represent hundreds of cubic feet of wood and tons of dry wood and bark.

Weight Per Cubic Foot.--An examination of green and dry weight per cubic foot of sample trees revealed that understory hardwoods are quite dense, and in many respects very similar to overstory trees of the same species. Total tree green weight per cubic foot of the species studied, other than yellow-poplar, ranged from 59.4 to 67.4 pounds per cubic foot (Table 4). Total tree dry weight per cubic foot for the same species ranged from 32.5 to 40.6 pounds per cubic foot. Green and dry weight per cubic foot values reported by Jett and Zobel (1975) for mature red maple, white oak, red oak, and hickory are about the same as our values for small understory trees of the same species. Our yellow-poplar trees were higher in green weight per cubic foot and lower in dry weight per cubic foot than mature yellow-poplar trees (Jett and Zobel 1975). Since our yellow-poplar trees averaged only 18 to 19 years old (Table 2), age may have influenced this relationship.

Table 4.--Green and dry weight per cubic foot of understory trees and related wood and bark yields by region and species

Species	Green weight/cubic foot			Dry weight/cubic foot			Dry wt. wood & bark[1/]	% less wood & bark than hickory
	Stem	Branches	Total tree	Stem	Branches	Total tree		
	Lbs./cu.ft.			Lbs./cu.ft.			Lbs.	
MOUNTAINS (NC)								
Yellow-poplar	52.5	55.2	52.8	22.5	24.7	22.7	860	32.1
Red maple	61.5	62.5	61.8	32.6	31.9	32.5	1,052	16.9
White oak	62.2	61.4	62.1	37.0	35.3	36.9	1,188	6.1
Chestnut oak	64.1	62.7	63.8	38.1	36.0	37.8	1,185	6.4
Dogwood	62.2	65.4	63.4	35.9	35.6	35.9	1,132	6.5
Hickory	59.8	56.4	59.4	38.0	34.4	37.6	1,266	--
PIEDMONT (GA)								
Yellow-poplar	59.0	59.6	59.1	24.6	25.5	24.8	839	32.4
Red maple	60.2	59.5	60.0	33.5	33.0	33.4	1,113	10.3
White oak	62.4	61.6	62.3	36.1	36.0	36.1	1,159	6.6
Southern red oak	65.0	66.2	65.2	38.3	39.2	38.4	1,178	5.1
Dogwood	66.7	69.3	67.4	36.2	36.1	36.2	1,074	13.5
Hickory	66.0	63.5	65.4	41.3	38.2	40.6	1,242	--

[1/] In one green ton of total tree chips.

With few exceptions, the species sampled in the Piedmont were higher in both green and dry weight per cubic foot than comparable species in the mountains (Table 4). Differences between mountain and Piedmont trees were particularly large for yellow-poplar and hickory.

Green and dry weights per cubic foot for branches were similar to those for stems at both locations (Table 4). Hickory branches were consistently lower than stems in green and dry weight per cubic foot, but yellow-poplar branches were consistently higher than stems. Other differences were only slight.

To illustrate the importance of tree density and moisture content, we used green and dry weight per cubic foot values to compute the yields of dry wood and bark that could be expected from one green ton of chips for each of the six species at each location (Table 4). Yellow-poplar yielded approximately 850 pounds of dry wood and bark out of 2,000 pounds of green wood and bark, while hickory yielded about 1,250 pounds. The other species were intermediate in yield, with values of 1,000 to 1,200 pounds. Since hickory had the highest dry wood and bark yield, we used it as a base and computed the percent less wood and bark that could be expected when a species other than hickory is harvested. Yellow-poplar, for example, contained an average of 32 percent less dry wood and bark per ton than hickory (Table 4).

Bark Percentage. The six understory species we studied contained 15 to 30 percent bark in the total tree (Table 5). Dogwood had the lowest bark yield (15.2 percent in the mountains and 16.9 percent in the Piedmont), hickory had the highest yield (26.9 percent in the mountains and 29.1 percent in the Piedmont). Southern red oak, sampled only in the Piedmont, also contained a large amount of bark (29.7 percent).

Table 5.--Bark percentage on a dry weight basis of understory hardwoods

Species	Bark percent (dry weight basis)		
	Stem	Branches	Total tree
		MOUNTAINS (NC)	
Yellow-poplar	18.8	29.8	19.8
Red maple	18.2	25.4	19.5
White oak	21.4	32.3	22.9
Chestnut oak	23.9	31.0	24.8
Dogwood	14.4	17.2	15.2
Hickory	26.5	30.4	26.9
		PIEDMONT (GA)	
Yellow-poplar	21.6	32.6	23.8
Red maple	15.0	21.4	16.7
White oak	27.2	38.9	28.4
Southern red oak	29.7	29.9	29.7
Dogwood	16.4	18.2	16.9
Hickory	28.6	31.3	29.1

Branches contained more bark than stems in all species (Table 5). This is the relationship generally found in larger trees, and was as expected. The smallest increase in bark percentage from stem to branches was in dogwood with only a 2 to 3 percent increase; the largest increase was in white oak with an 11 percent increase.

With the exception of red maple, trees sampled in the Piedmont contained more bark than the same species in the mountains. It is not clear why this difference exists. Differences in bark yield of hardwoods by species, age, and location are not well documented even for mature trees.

DISCUSSION

Understory hardwoods represent an untapped and potentially valuable source of additional fiber for the paper industry. An examination of the understory of mature hardwood stands revealed that dense hardwoods such as oak, hickory, and dogwood dominate in the 1- to 5-inch d.b.h. category. These trees often occur in large numbers and represent a tremendous amount of volume when considered as a group.

Wood and bark yields per unit volume of understory trees are equivalent to those of overstory trees. This finding is not surprising when one considers that most understory trees are suppressed and often quite old. Our sample trees ranged in average age from 18 to 44 years old, although average diameter was only three inches.

LITERATURE CITED

Barker, R. G. 1974. Papermaking properties of young hardwoods. Tappi 57(8): 107-111.

Cost, N. D. 1974. Forest statistics for the mountain region of North Carolina. USDA For. Serv. Res. Bul. SE-31, 33 pp. Southeast. For. Exp. Stn., Asheville, NC.

Jett, J. B. and Zobel, B. J. 1975. Wood and pulping properties of young hardwoods. Tappi 58(1): 92-96.

Knight, H. A. 1972. Forest statistics for north central Georgia. USDA For. Serv. Res. Bul. SE-24, 34 pp. Southeast. For. Exp. Stn., Asheville, NC.

Sollins, P. and Anderson, R. M. 1971. Dry-weight and other data for trees and woody shrubs of the southeastern United States. Ecol. Sci. Div. Pub. No. 407, 80 pp. Oak Ridge Nat. Lab., Oak Ridge, TN.

PRODUCTION OF QUALITY HARDWOODS BY THE LARGE FOREST INDUSTRIES

By Bruce Zobel[1/]

Although there is no proof, I would estimate that over 50% of the top-quality hardwood timber from the large timberland owners never finds its way into the quality wood market. Additionally, much of the very best hardwood land is not producing quality timber for the future. Reasons for lack of emphasis on quality hardwood production by the large forest industries are too many and too complex to cover more than superficially in this paper, but I will discuss a few of the most important. These can generally be related to previous land management practices, to ignorance of the value of quality hardwoods, to lack of markets in the right place, to antiquated and unreliable methods of timber-buying by those using quality logs, and to plain lack of concern.

Although the forest industries control only 13% of the merchantable forest land in the South, they own some excellent hardwood land capable of producing top-quality logs of the most desired species. Published data indicate that half of the 200 million acres of commercial forest land in the South is classified as hardwood forests, and half of this acreage (50 million acres) is suitable only for hardwood production, not easily converted to pine management, agriculture, or farming. The large industrial landowners control a much lower proportion of hardwood lands than the 50% reported above; based upon a recent survey of the 30 industries that are members of the Pine and Hardwood Cooperatives headquartered at N. C. State University,[2/] members report that only 27% of the 19 million acres under their management in a 13-state area should be considered pine and hardwood lands, but it is evident that the larger corporations generally control a higher proportion of the more operable pine lands than is found overall throughout the South.

Despite this low ratio of hardwood forest land relative to the overall South, the large landowners control some exceptionally good hardwood lands, some stocked with high-quality timber. It is clear that these are not being used to their fullest potential, relative to either current harvest or in forest land productivity in the long run. Why is this so?

[1/] Professor of Forest Genetics, and Head, Pine and Hardwood Cooperative Programs, N. C. State University, Raleigh

[2/] The Pine Cooperative is supported by 28 industries and three state forest service organizations in a 13-state area; the Hardwood Cooperative by 19 industries and one state forest service. Current hardwood planting program of the members is 6,700 acres/year.

1. History of Land Management

A considerable proportion of the lands owned by the large corporations were medium-sized holdings purchased from independent sawmill owners. For the most part these forest lands have been selectively logged for prime trees of certain species so intensively and for such a long time that the forests on them are in an advanced stage of degradation. It is exceedingly expensive to convert such "beat-up" stands to the desired stocking of the desired species, and most (but certainly not all) industries are continuing the practice of "selective logging." The suitable sites are converted to pine, and the hardwood sites often are left to grow untended, relying on Nature to regenerate them as chance would have it. Most "selectively logged" stands are less than 50% efficient in producing quality hardwoods, and many are so completely degraded that the production of quality timber is essentially nil. This status of hardwood stands is most prevalent on the extensive, very high site, coastal river bottomlands, and on some of the best Piedmont stream bottoms.

The very practical question relates to how these degraded stands can be economically converted so they have a good stocking of the desired species. Some cannot if only natural regeneration is used, because they are so degraded or costs will be so high that it is not economically feasible. However, the bulk of the best hardwood lands can still be converted to high production if there is the will and commitment stemming from a real incentive. Some must be salvaged by clear-cutting and planting, but other of the best sites are not conducive to any kind of mechanical site preparation. The key to forest renewal in most instances relates to the removal of cull and undesirable species to give room for the establishment and development of the best species. Usually, however, the uncontrolled stocking results in too dense stands, requiring expensive precommercial stocking control or economically marginal thinning operations if large quantities of high value timber are to be produced within a reasonable time period.

2. Lack of Appreciation of the Value of Hardwoods For Other than Pulpwood

It is very disturbing to see the amount of prime quality hardwoods that are converted to chips for pulping. Following sharp questioning, it usually becomes clear that the man in charge either does not know the value of quality hardwoods or he doesn't care. Pressures are so great to keep the pulp mill or wood yard at full operation that the boss frequently is not willing to interrupt a smooth flow of raw material to keep the chipper going by removing the quality logs. Sometimes the problem is at a higher administrative level where the boss looks with disfavor on hiring extra men, equipment, and effort to sort out quality logs.

Two incidents I recently encountered illustrate what sometimes happens. While walking in the wood yard of a mill manufacturing a low-quality pulp I saw a number of top-quality cherry and even a few walnut logs going to the chipper. When questioned, the foreman explained that it was his job

to keep the chipper going and his boss didn't encourage sale of the quality material because it was inconvenient. A similar answer was given at a wood yard where some magnificent white oak stems had been cut into 5-foot pulpwood bolts. The logger informed me he got the same price for these as for small logs, they weighed out heavy, and he was not the least bit perturbed at the use of high-quality logs to produce low-quality paper. It is understandable why some people become righteously indignant at what they consider misuse of a limited valuable resource, but the problem is complex as discussed below.

3. Lack of Suitable Outlets for Quality Material and Insistence on Full Log Lengths

Almost like a broken record, especially along the coast and some of the major river drainages in the mid-South, I hear the lament, "Where can I sell my quality hardwoods?" or, "Those so-and-so's want to rob me and will pay for only perfect 16-foot length logs." They point to a 6-, 8-, or even a 10-foot section of magnificent timber and then inform me that there is no sale for such short logs.

There are areas in the South where it currently appears that quality timber cannot be sold, no matter how good it is. Distances to buyers or converters are so great that transportation costs make shipping uneconomic. Buying practices are antique at best, unreliable and sometimes downright dishonest. No corporation is willing to interrupt a smoothly functioning chip supply, buy the equipment and gear up to sell quality logs when it suspects that, even though there is a market now, it will disappear six months or a year from now. This relates to the unreliable system of small loggers and dealers selling to the manufacturers through brokers or a middleman. As one manager of a furniture factory expressed it, the wood is "worn out" from handling by the time it gets to be a piece of furniture. The larger manufacturers of solid wood products have been unwilling or unable to singly or cooperatively set up a buying and supply system that is reliable and efficient enough to assure a constant flow of desired wood. The result is that somewhat cheaper timber can be obtained, using current practices, but this is at the sacrifice of the use of quality material to make products for which low-quality trees are satisfactory.

Why do logs have to be so large, so perfect, so roundly formed when smaller-diameter timber as shorter logs can serve the same purpose? There are loud laments about the utter foolishness of the Organic Law of 1897 and its effect on hardwood, but in many ways the requirement for only prime logs by some hardwood manufacturers is just as unrealistic; there must be an acceptance of somewhat smaller trees and shorter logs.

4. Is It Economical to Grow Quality Hardwoods?

The usual and immediate answer sometimes snapped at me by the corporate landowner is "No!"

This attitude has been fostered by a lack of knowledge as to the time it takes to produce timber that can be used for quality products. Under unmanaged conditions, rotation ages of 80, 90 or 100 years are required to grow trees considered to be of suitable size and quality. If this length of time is required, I'll agree that one can't economically grow quality material. But if land is well managed and properly stocked with good trees, such long rotations are not necessary; to be successful this must be accompanied by the acceptance of somewhat smaller trees and shorter logs. Our studies indicate that hardwoods on good sites can be grown to a usable quality and size in 30 to 45 years; a longer time period becomes economically unjustifiable because of the sharp upturn of the interest curve with added years. Many people "cop out" with the attitude, "Let the government grow the big timber." It is no more economic for the government to use long rotations than for industry, and ultimately it is the public who pays. Currently there is question as to how much large timber will be available for market use even if the government does grow it!

Interest in hardwood management in the forest industry is on the upswing. Plantation establishment, especially in the coastal areas and main river basins, is expanding rapidly, and within our Hardwood Cooperative 6,700 acres are being planted each year. The immediate reaction to plantation management evident from many persons interested in quality wood production is one of disinterest because they feel plantations are intended only for short-rotation pulp production. But this is not necessarily so! As the plantations come into harvesting size, a decision must be made whether to clear-cut or thin; if the latter is done, quality stems for solid wood products can be left and their growth favored. I can see this option being strongly exercised in the future if there is a good and reliable market available for logs from trees in the 30- to 45-year class. Our opinion is frequently sought about this option as intensive hardwood management becomes more widespread. The possibility of growing quality hardwoods is certainly under consideration, but availability of reliable markets is always a point of discouragement. Without knowledge that markets for solid wood products will be available and stable, the choice will be for pulpwood and clear-cut plantations at young ages. The decision as to thin or clear hardwood plantations is still some time in the future, and the final disposition will be determined by market demands and prices.

The Solution--Summary

There is no simple solution, but many difficulties can be overcome by simple liaison with an exchange as to needs and available timber. The current complaints by the large landowner that markets do not exist or by the buyer that timber cannot be obtained can be largely overcome by exchange of information and realistic and stable timber-buying policies. The technology exists for utilization of short logs of moderate size but as yet is not widely applied.

Better prices for timber will help in obtaining more quality logs but this could become counterproductive for the buyer if prices get too high. There is no question about the availability of a good supply of usable timber in the future. This partially results from the current environmental emphasis, which results in leaving timber strips and stream buffers; timber from such

areas will be relatively large when harvested. The difficult-to-log, swampy and mountainous areas will produce trees of good size before timber extraction can be efficient. We will continue to have hardwoods. In a recent paper, John Muench says, ". . . the volume of hardwood timber supply is generally adequate to supply domestic product demands."[1/] If this supply is used wisely, if better utilization is achieved through employing a short-log system,[2/] if markets are available for the available timber, if people can be educated to the value of quality hardwoods, and if higher values are paid and younger trees used, the large forest landowner will make a major contribution to the supply of quality hardwoods. Although the very poor condition of the best hardwood stands, especially along major river drainages in the Coastal Plain and Piedmont, makes it difficult to obtain good stands of desired species, many can be converted with some effort and expense.

As an outsider looking in, it seems to me we need less complaining, more common sense, more planning and a major effort at communications between the grower and the user. The large forest landowner will grow quality hardwoods but he will not do so unless a better system of supply and demand can be established which will benefit both the grower and the user. There are millions of acres under control by large forestry concerns capable of growing quality hardwoods or with quality hardwoods already present. Needed now is the incentive to manage lands for that special product.

1/ Muench, J. 1975. Taking the pins out of foreign policy. S. J. Hall Lectureship in Industrial Forestry, Univ. of Calif., Berkeley. April. 8 pp.

2/ Dowdell, S. A. and Plotkin, H. S. 1975. A pilot operation to determine the feasibility of operating a short-log system in western North Carolina. Hardwoods Forestry Note No. 15, N. C. Forest Service, Raleigh, N. C.

THE FEASIBILITY OF USING SHORT LENGTH LUMBER IN FURNITURE MANUFACTURE

by

Samuel A. Bingham, Associate
Ross Associates, Inc.
Asheville, N. C.

INTRODUCTION

It has long been recognized that much of the tree cut in the forest is either left in the forest as residue or delivered for less-than-optimum value uses. It has been repeatedly demonstrated that the manufacture of furniture is a high value use which can largely be supplied from short or irregular sections of a tree. (1, 2, 3). It is also recognized that the furniture industry has not been utilizing these sections in any quantity. An appalling amount of wood suitable for furniture is left in the forest or sent to the chippers.

The U. S. Forest Service and Ross Associates undertook to determine what might be done to bring about such utilization in currently operating furniture plants. It was agreed that three areas should be explored. These were:

1. How can prices for short length lumber be equitably established?

2. What are the problems to be encountered in handling of short lumber?

3. Are there any unique problems associated with the drying of short lumber?

The study consisted largely of the review of what has already been done on the subject of short lumber

MEETING THE NEEDS WITH SHORT-LUMBER

A popular belief exists that furniture cann be built from short lumber. This belief probably arises from the difficulty of obtaining sufficient long cuttings from lumber presently being purchased. The bulk of furniture parts are quite short. For example, an analysis of one set of cutting bills (6) shows 96 percent of the pieces can be cut from 42-inch lumber. The average cutting length was 24 inches.

Another analysis of a full-line cutting bill representing an annual usage of three and a half million board feet of lumber showed the average cutting length was 23 inches. (6a).

In a third study, an entire year's production of a major (6b) manufacturer of a full line of furniture, including chairs, (but not upholstered furniture) was analyzed. This manufacturer used one and a half million net board feet of four-five-six-and-eight quarter lumber. The average cutting length for this operation was 31 inches. A breakdown of this company's production by cutting size is shown in Table 1.

Table 1

66.3%	of the board foot requirements were less than	36	inches long
77.4	"	42	"
85.4	"	48	"
92.0	"	54	"
95.4	"	60	"
98.9	"	66	"
99.1	"	72	"
99.9	"	78	"
100.0	"	84	"

Average cutting length 31"

It is clear that the bulk of furniture requirements can be met with short length lumber. The relatively few long cuttings can be obtained from higher grade, long lumber purchased specifically for this purpose.

PRICING

Long-length lumber (8 ft. - 16 ft.) is widely traded and identified by standard rules so that a buyer can compare quotations from various suppliers and know with reasonable certainty what he will get.

No such system or experience has been developed for short lumber less than 8-feet in length. There is no "market"; there are no rules; a buyer has no standard descriptions to use in writing his purchase order; he does not know what he will receive; and he does not know what his processing costs will be. Since he has no common denominator, he does not buy short lumber.

EXISTING RULES

The National Hardwood Lumber Association rules do include short lumber in their standard grade descriptions, but very limited quantities are allowed and severe grade restrictions prevent their application to lumber as might be developed by a short lumber mill. The standard rules allow only small percentages of short length lumber in shipments:

FAS None under eight feet.

SEL Five percent may be six to seven feet.

#1 C Ten percent may be four to seven feet of which only half may be less than five feet.

#2 C Thirty percent may be four to seven feet, of which one third may be under five feet.

These limitations obviously do not allow a shipment consisting of lumber which is all 7-feet or shorter.

The only NHLA rules for really short furniture stock are designed for partially or fully machined dimension parts.

"Milpak" does not cover the requirements either. There is only one grade, which allows an unacceptable mixture of defects.

During the course of this study, only three situations (7, 7a, 7b) were found where short lumber changed hands and required that prices be established. In each, pricing was to be based upon the producer's and user's findings AFTER the lumber had been used. All three were research projects of a sort, and none of these has yet developed into an on-going situation.

In each of these situations, however, it was expected that on a part-for-part basis the price of the short lumber would be substantially below that for long lumber. This lower cost was expected to be due to several factors:

A. Short lumber would be produced from one of three sources not now fully utilized:

   1. Wood now left in the forest,

   2. From good short logs or bolts now converted to chips and sold for a lower unit price, or

   3. From saw logs that would normally produce only low-grade lumber but which, if bucked to shorter lengths, would produce lumber of a higher quality.

B. Greater lumber yield is expected from short logs as there is less waste due to taper (10) and crook or sweep.

HANDLING

One of the major objections to the use of short lumber by the furniture industry has been the prospect of "handling so many pieces". With short lumber averaging four feet in length there are three times the number of pieces to handle than with the same volume in lumber averaging twelve feet in length. There are more pieces to be graded, counted, stacked and fed into the cut-off saw. Short lumber results in more packages to be moved. Normally each package of short lumber must be handled by itself as with long lumber, so that with short lumber the fork truck operator is busier and much of the regular fork truck's capacity is un-utilized.

Six, seven and eight foot boards which are currently occasionally mixed in with long lumber packages are often troublemakers on the haul-up chains and tilt hoists, readily scrambling or falling through. Really short pieces simply cannot be handled on some of the existing equipment. There is no question but that handling of short lumber poses problems for the present day furniture factory up to the cut-off saw.

DRYING

Individual manufacturers and processors of lumber in the North-eastern section of the U. S. have developed a considerable amount of practical information relating to the drying of short lumber. Among the research community, however, Rice (20) and Redmond and Willard (21) are the only ones who appear to have published the results of their work on drying short lumber. The majority of the practical experience concerns squares and planer boards but should be applicable to short lumber.

There is strong evidence to indicate that the drying schedule for short lumber should be somewhat milder than that used on long lumber (25, 27, 28). The milder schedule reportedly minimizes shrinkage and hence reduces warping (23, 25).

Apart from the almost universal agreement on milder schedules there is little agreement on how these should be obtained; and there is not even complete agreement that they are necessary.

However, one company (22) is mixing short lumber in the long lumber packages. They dry 6/4 lumber on a Forest Products Laboratory schedule; 4/4 is speeded up and 8/4 is slowed down from the corresponding FPL schedules. At this plant, ends within the package are butted together and not end-coated. Exposed ends of both short and long lumber (at the ends of the packages) are coated.

End checking can seriously affect yield. It has been found that end checking without proper care of the lumber averages about 5 inches, or three and a half percent of a 12-foot board. A five inch end check in a 42-inch board is 12 percent. Obviously, it is necessary to take precaution to minimize end checking.

As we have indicated, we could find little in the literature on the drying of short lumber. None has been found on the drying of short lumber in the South East with its different climate. The

unknowns of drying constitute another reason present furniture plants are reluctant to use short lumber.

Up to this point we have reported some of the difficulties that are keeping short lumber from being used by currently operating furniture plants. They are sufficient to deter management which has enough problems without taking on these new ones. In review, these difficulties are:

1) A lack of a generally accepted specifications for short lumber.

2) Problems of handling short lumber.

3) Lack of sufficient information on drying.

and 4) Because of lack of demand there is a lack of adequate commercial sources of short lumber.

SOLUTIONS

Short Lumber Rules

Now let's take a look at some of the possible answers to these problems. A new system of specifications is needed for short lumber, a system that is geared to the needs of the furniture industry.

Basically these needs can be met with four classifications, and some rather simple limitations in these four. These classifications are: Clear, Clear one side, Sound, and Paintable. There should be limitations on width and length, wane, and stain. Length specifications should be based upon both an analysis of normal cutting length requirements and upon availability of minimum defect bolts.

There are twice the mumber of possible cutting combinations (10 inches to 42 inches long in one-inch intervals) from a 42-inch board than from a 36-inch board. Thus, the 42-inch board is more desirable. The number of combinations climbs rapidly as the length of the board increases. This is one of the reasons why the furniture manufacturers have traditionally liked to work with long lumber.

Standard pallet deck boards 42-inches in length, a short-lumber use, constitute a high volume outlet for short lumber that will not meet furniture requirements. Yet, they still bring higher returns than do chips. The increased number of potential cutting options, the work of Koch, et al, and the high volume production of pallet parts indicate that the minimum short lumber length should be 42-inch.

However, there will be bolts that will not produce high-grade 42-inch lumber, but which would produce good, useful 36-inch lumber. For this reason, it is suggested that the short lumber grading rules make provision for some 36-inch lumber in a shipment.

With a range of possible bolt lengths from 36 inches to 16 feet, the lumber manufacturer would have the flexibility to defect tree stems to the greatest advantage.

We anticipate that the resulting short lumber, sorted and packaged by grade and by length, will offer a substantial advantage to lumber users. These packages will stack neatly on the yard, in the kiln, and in dry lumber storage and will result in an economy of space. Being sorted by grade and by length, furniture parts may be partially machined automatically.

Based upon the above considerations, we are submitting here a tentative set of rules to serve as a basis for discussion.

PROPOSED SHORT LUMBER GRADING RULES

Standard Lengths: 36" 42" 48" 54" 60" 66" 72" 78" 84" to be sorted and packaged by length and grade.

Tolerances: Minimum, 10% of the pieces permitted to be standard lengths minus 1 inch. Maximum length of all pieces to be standard lengths plus 2 inches. Boards totaling 15% of the 42" footage may be 36 inches.

Standard Widths: 20% of the total number of pieces of a given length may be less than 4 inches but not less than 3 inches wide. The balance must be 4 inches and wider.

Thickness: Thickness shall be the same as in the NHLA rules. Standard Major Defects shall include knots (both loose and sound), shakes, checks, pith, bark, pockets, worm holes, rot, bird pecks, burls

Grades: There are, in reality, only four possible basic grades for furniture construction, according to the four possible uses. These four uses and the corresponding basic grades are as follows:

Clear - for exposed furniture parts.
The piece shall be clear two sides and two edges. Stain shall not be permitted. End checks of 1/2-inch allowed. Length, Width: Standard; Wane 1/8-inch maximum on two edges.

Clear one Side - for semi-exposed furniture parts.
The piece shall be clear one side. On the opposite side sound knots, bird pecks, stain, surface checks not materially impairing the strength, pin holes, shot holes, and spot worm holes shall be permitted. One-quarter-inch wane is permitted on two edges.

Sound - for furniture interior parts.
The piece shall be free of rot, pith, and shakes. Sound knots, bird pecks, stain, surface checks not materially impairing the strength, pin holes, shot holes, spot worm holes shall be permitted. One-quarter-onch wane permitted on two edges.

Paint Grade - for exposed painted furniture parts.
Same as clear-one-side except that stain shall be freely admitted.

A set of rules designed to cover short lumber marketed specifically for furniture manufacture will go far toward relieving the problem of establishing market prices. The seller would be made familiar with the buyers' needs and the buyer would know what to expect and could choose the proper grade and length to meet the requirements of his end-use.

SHORT LOG RULES

The proper production of short lumber can be enhanced by the careful production of bolts -- which, in turn, requires the more intelligent handling of the tree stem. To aid in the evaluation of the whole tree stem, a universal short-log grading system is needed. At present, this is absent and there is no generally accepted way of evaluating the potential of a bolt as there is with saw logs.

Dunmire (15) developed a set of bolt grades and Kroon (16) has modified them. However, neither has gained official or general recognition. Further work is necessary to develop a universally accepted system.

It has been found by several researchers that the Doyle, the Scribner Decimal "C" and the 1/4 International log scale rules (1, 17, 18) are inaccurate in the small diameters and short lengths. It would appear that either a new scale or modifications of the existing scales is in order.

The "defecting" of tree stems into best use sections has been found to increase the quality of saw logs and the quantity and quality of the resulting lumber, both short and long (19, 1). Crook and some of the other defects are removed or minimized, and the reamining sections are straighter and clearer. The creation of reliable bolt grade rules and scales will aid in the general understanding of these potentials.

Equipment for handling, bucking, and converting tree stems in accord with this principle is available and in operation. A plant constructed on this principle would include debarker, possible both long and short-log sawmills, bolter saws in tandem with a re-saw "merry-go-round" and, of course, a chipper.

HANDLING

As we mentioned earlier, one of the major objections to the use of short lumber by the furniture industry has been the prospect of "handling so many pieces". Fork trucks, grading and stacking equipment, tilt hoists, and haul-up chains are usually designed for lumber eight to sixteen feet long. These <u>are</u> quite valid objections to the use of short lumber. But there <u>are</u> factors that minimize or offset these objections.

Huffman, (2) Huber and Kroon (16) have found that cutting yield from short lumber runs from seventy to eighty-five percent while the yield of comparable Number One Common lumber runs sixty percent.

Thus, a smaller volume of short lumber is handled to get a yield equivalent to long lumber. Package density averages 90% with short lumber compared to about 70% in conventional stacks; this further reduces the number of packages and their moves. Wherever pieces are manually handled, short pieces can be moved faster and with less fatigue than long pieces. Rice (20, 20A) reported that hand stacking of green dimension took no longer for a given volume of cuttings than did the stacking of conventional long boards.

Yards can be re-arranged so that small packages are placed where the handling distance is the least. Packages, being smaller require smaller handling equipment which can operate in smaller spaces. Thus, better use can be made of a given area.

Equipment such as stackers and tilt hoists, and their associated transfer chains can be modified by the addition of chains and forks to handle short lumber. Lumber lifts seldom need modification.

The evidence does not indicate that all the factors mentioned above can offset the extra costs of handling more pieces. An answer lies in the consideration of the whole problem from tree to dimension. It often proves economical to spend a bit more in one part of a process to gain greater benefits in the overall operation.

DRYING

In the matter of drying, the consensus appears to be that all of the good methods which should be used in drying of long lumber but often are not MUST be used with short lumber. Uniform stickers, properly placed near the ends of the boards, and accurately aligned vertically within the stack and adequate in number - preferably twelve inch centers, are needed. End coatings as soon as possible after the bolt is made are recommended by most of those surveyed. Accurately cut lumber is essential to provide flat boards after drying, and to insure the stability of short-lumber stacks.

With regard to kiln drying, we have mentioned that there seems to be a variety of experiences, but little in the way of documentation of formal controlled tests. The nearest thing to a concensus is that generally a milder starting schedule is advisable. We believe that this is an area where some research is advisable.

It was noted earlier that short lumber sorted by length will permit a pile density of about 90 percent versus about 70 percent for long-lumber box piled. More lumber would be dried in a given space and time. There is less air by-passing within the packages. A still further advantage is that short packages give more options in kiln loading so there may be fewer voids and thus less by-passing of air between packages, and increased kiln loading.

These factors, coupled with the expected high cutting yield, should effectively increase the capacity of existing kilns or reduce the required capacity of new kilns, and tend to offset the longer drying times indicated by the possible milder schedules.

PROJECTION

Economics of Short Lumber

The future attractiveness of short lumber for furniture manufacture will, of course, depend entirely upon economics. It appears to us that savings can be made in the basic cost of lumber through the use of wood that is now left in the forest, or is sold for much lower-priced uses. It appears that handling may be slightly more costly than the handling of a similar footage of long lumber. Some savings can be expected in the drying, though, because of denser packages, better kiln loading, and improved yield from the short lumber. Up to this point, no operation has been eliminated or simplified significantly. Substantial savings are possible after drying, however.

With proper tree length defecting and new grading rules, bolts and resulting lumber may be of such quality and quantity that most of the furniture part requirements could be supplied from short lumber. Only some extremely long cuttings need be supplied from long lumber, the cutting of which could be made from the higher grades of lumber with simple equipment. Thus, most of the handling machinery could be designed for lumber less than eight feet long.

By pre-sorting the short lumber by grade and by length, it would be possible to use automatic, high production machinery to do the jobs of cutting to length, facing, planing and first ripping. This would eliminate two operations where pieces are conventionally handled individually and where present day plants employ many men in a less-than-desirable work environment. In addition, it would reduce the size and cost of the heavy, space consuming tilt hoists and their related equipment. A tilt hoist and chains for handling lumber under eight feet long would cost less than 80 percent of the conventional equipment. A 10,000 pound fork truck could be used in place of a 22,000 pound unit, at a saving of up to $20,000. There are some very substantial savings to be made here.

The T-D Concept

Up to this point, we have discussed the manufacture of short lumber at one location by one owner and the transfer of that lumber to another location or owner, usually both. This involves the problems of grading, pricing, and transporting the material. The latter includes the transport of half of the material which ultimately becomes waste, and of the transport of large amounts of water.

The alternative, which we call the Tree-to-Dimension ("T-D") concept, is to move the conventional Rough End from the furniture plant to the sawmill. The whole operation from the tree through the rough dimension would be placed under one management. This plan would permit better utilization of the tree, and of the lumber cut from the tree.

6. Reliable cost figures have not been developed to create the interest needed by furniture manufacturers to solve the above five problems

From the standpoint of furniture plant management, solving of any three of the first five problems would not be enough to develop the use of short lumber. But a favorable solution of No. 6, the lack of reliable cost figures, might be enough to force the solution of all the others.

The resulting system, we believe, will evolve to be as follows:

1. The areas of management interests will be refined to bring the preparation of the dimension blank from the tree tree under one head, and the sawmill, kilns and the Rough Mill will be located at the same site.

2. Realistic short log and short lumber grading rules will be established.

3. Tree lengths will be harvested and then bucked into best-use elements (veneer logs, long lumber logs, short lumber bolts, pulp chips).

4. The bolts, short logs and standard logs will be sawn on equipment which will include bolter saws (often in tandem with re-saw merry-go-rounds), and possibly short log saw rigs.

5. The lumber will be dried in the best combination of yard, pre-dryer, and/or standard kilns.

6. The lumber cut-up facilities will be designed to automatically cut to length, face and plane, and first rip.

7. The larger furniture manufacturers will integrate backwards into the woods under the "T-D" concept.

8. The smaller companies will purchase rough and semi-dimension from commercial "T-D" suppliers.

The solution to the problem of the use in furniture manufacture of the un-used or under-used parts of the tree lies in the solution of all of the problems along the way, not merely the advantageous solution of individual problems. When these have been solved, the resulting cost savings should make it attractive to utilize wood now being left in the forest or converted to less valuable uses.

The "T-D" plant could fit all suitable lumber into the plant's requirements without regard to grading rules. The parts produced by the "T-D" plant would then be governed by the NHLA and HLMA rules for dimension parts or by the furniture plant's own specifications.

Under the present system, the logger looks at logs, the sawmiller looks at lumber, the Rough End Foreman thinks of rough dimension, and the furniture plant management looks only as far back as the lumber yard. In the "T-D" concept, the division of management interests change; handling of the produce from Tree to Dimension is under one management which understands and looks at all phases of the operation. It is concerned with making furniture parts from the tree, not merely from a piece of lumber.

Major parts of this "T-D" concept are being applied successfully by a number of companies.1/ These companies have combined sawmills and partial or complete Rough Ends. This puts the entire manufacture from tree to dimension blank under one layer of management.

CONCLUSION

The question which prompted this study asks, in effect, "what is keeping contemporary furniture plants from utilizing short lumber that can be made from presently under-utilized or un-utilized parts of the tree?" In essence, the reasons are these:

1. There are no recognized yardsticks by which buyers and sellers in the open market can evaluate the quality of short lumber.

2. Handling equipment in the average furniture plant is not able to readily accommodate short lengths without modification.

3. Proper drying procedures for short lumber are not well known.

4. There are no present markets for short lumber and few suppliers are able to produce it even for experimental purposes.

5. The furniture plant manager has a background of using long lumber and problems associated with it have generally been resolved to his satisfaction, and he has neither the time nor the inclination to take on new problems.

1/ Gamble Bros.
Moosehead Mfg. Co.
Ethan Allen Co.
S. Bent & Co.
Nichols & Stone
Sklar Mfg. Co. (Canada)
Dominion Electrahome (Canada)

BIBLIOGRAPHY

1. Hamilton, J. F., 1970. Maximum tree use - new concept for hardwood dimension production. Institute of Wood Research, Michigan Tech University.

2. Huffman, J. B., 1973. Comparative yields of furniture parts cut from short bolts and conventional logs of Florida red oak. Div. of Forestry, Florida Dept. of Agriculture.

3. Landt, E. F., 1974. Aspen volume tables for furniture-type flat 4/4 dimension from small low-quality trees. U.S.F.S., North Central Station, Research Note 166.

6. Flann & Bousquet. Sawing live versus round.

6a. Ross Associates, 1974. Analysis of Pennsylvania House.

6b. Ross Associates. Analysis of Vilas Industries, Ltd.

7. Kroon, M. J., 1974. Sawing furniture quality dimension from short log bolts. Master's thesis, Michigan State University.

7a. Pryor, J., 1974. Carolina Timber Co., Plant visit.

7b. Weis, B., 1974. Weis, Fricker (Pensacola, Florida, Telephone interview.

10. Koch, Galliger & Jackson, June 1968. Yield from sprout black cherry trees sawn with short log bolter saw. University of West Virginia.

15. Dunmire, Brisbin, Gale & Sherwood, May 1974. Furniture square yields from graded maple bolts. U.S.F.S. Hardwood Research Council Proceedings.

16. Huber, Michael and M. J. Kroon, 1974. Sawing furniture quality dimension from short logs. Dept. of Forestry, Michigan State University.

17. Landt, E. F. Black walnut volume tables for furniture-type flat, 4/4 dimension from small, low quality trees. U.S.F.S. Research Note #168.

18. Bennett & Lloyd. Volume of saw log residue as calculated from log rule formulae. U.S.F.S. Bulletin SE-118.

19. Bellamy, T. R. Pulpwood prices in the southeast. U.S.F.S. Research Note SE-205.

20. Rice, W. M., December 1964. Kiln dry dimension parts instead of boards. Southern Lumberman.

20a. Rice, W. M., September 1968. Hardwood dimension drying - is it feasible? Woodworking Digest.

21. Redmond & Willard, 1957. Short log bolter for furniture stock.

22. Stecher, D., May 1973. Processing the tree into optimum products. Andover Wood Products. Hardwood Research Council Symposium.

23. McMillan, J. M., Stresses in wood during drying. U.S.F.S. Report No. 1652.

25. Welford, Walker. Moore of Oregon - Memphis (phone).

27. Catterick, James. Irvington-Moore Co. (phone).

28. Gale, Ronald. Pennsylvania Department of Environmental Resources, letter 1974.

FURNITURE PARTS FROM PULPWOOD - A PLANT THAT DID IT

by

Hugh W. Reynolds, Engineer
USDA Forest Service
Forest Products Marketing Laboratory
Princeton, West Virginia

Sam Bingham has told you about the problems and potentials for the use of short lumber in making furniture. I will tell you of our manufacture of short lumber and its use in a new type furniture plant. This work was done as a scientific study--laboratory and industrial data were obtained. The work was successful. The short lumber sawmiller and the furniture manufacturer are trying to get together on price and quantity. So in this case it is not a question if short lumber can be used, it's a question of when the lumber demand will rise so that the short lumber must be used.

From this work came three results. The first result: yellow-poplar logs that are normally used as pulpwood provide a good source of 6-foot sawbolts. These logs are good enough so that very little bucking for grade is required. This is definitely not the case for all species used for pulpwood, but it is true for the poplar. The second result: the sawmill making pallet parts from pulp bolts can also make short lumber for furniture use. The pallet part sawmill is an inexpensive way to break down logs to lumber. The quality of the short lumber depends on the short log quality not in the way the bolt is sawn. The third result: short lumber can be directly substituted for regular lumber in this furniture rough mill. No changes in handling, drying, or rough mill operation are required when the short lumber is used. If the short lumber is competitive in price with long lumber, the furniture product costs will not increase but will decrease.

There is a lot to cover in 25 minutes. So let me quickly tell you what we did and then let you ask questions in the remaining time. I want to cover the way we selected the bolts, the pallet part sawmill used, and the yield of short boards obtained. Also how we handled the green boards and how they were dried. I want to briefly discuss the furniture plant's rough mill, its research and design. Then to tell you of the yield of interior parts from kiln dried boards. Since this is a lot to cover, I will not use slides--instead, I will have some publications to give you and a sheet with the pertinent data in this talk.

Champion International has a pulpwood yard at Rosman, North Carolina, about 40 miles east of here. Random length logs and 5-foot pulpwood are bought at this yard. The pulpwood is shipped as 5-foot logs to the Canton, North Carolina, papermill. The longer logs are chipped without debarking and the chips are trucked to Canton. Jim Schroeder, of the USDA Forest Service in Asheville, supervised the bucking out of seven cords of yellow-poplar bolts, 6 foot 3 inches long, from the random length logs. The bolts were from 6 to 12 inches in diameter with about a cord in each inch diameter class. The predominate range of diameters available was from 7 through 11 inches so we only got a half cord of 6- and 12-inch bolts. We got 205 sawbolts that totaled 570 cubic feet of solid wood and scaled 2900 board feet. Bolt scale was 1/4-inch International rule to the nearest board foot. Very little selection was used in bucking the bolts. Only the very largest defects or the most pronounced sweep was avoided. What Jim did could be easily accomplished by a slasher saw in front of a chip harvester.

We brought the sawbolts to a modern, 20,000 board foot per shift, short log pallet part mill in southern Virginia. This mill operates with 4-foot pulp bolts and does not debark. The bolts are centered and are fed through a Scragg headrig where the two saws, permanently set, make two slabs and a 3-3/4-inch thick cant. The cant is sent to a single arbor circular gang resaw where the cant is made to 1 and 2 inch pieces in a single pass. The slabs go to a horizontal band resaw merry-go-round. Here each slab is sawn to as many 1-inch boards as possible. The boards are edged to 4 or 6 inch widths or to a combination of 4 and 6 inch widths in a single pass. All boards are sent through trimsaws set at 48 inches to complete the process. Only three changes were required to make our short lumber: (1) 6-foot 3-inch long bolts were sawn, (2) only 1-1/16-inch thick boards were made, and (3) all boards were trimmed to 72 inch length.

These kinds of sawmills are very efficient for the pallet industry. One such mill in northern West Virginia pays a 25 percent premium for pulp bolts and the resulting pallet parts ready for assembly cost half of the normally produced parts. We were able to obtain this benefit of low cost sawmilling with our yellow-poplar bolts.

The 205 sawbolts were converted to 3370 board feet of short lumber. This was a 49 percent volumetric yield, an LRF of 5.9 board feet per cubic foot, or a 15 percent overrun from 1/4-inch International scale. This is 16-1/2 board feet of short lumber per average bolt. For an 80 cubic foot of solid wood per cord of sawbolts, the yield is 470 board feet per cord. The short lumber grade is estimated at 13 percent No. 1 Common, 71 percent No. 2 Common, 12 percent No. 3A Common, and only 4 percent less than No. 3A. We were very pleased with this recovery both in quantity and in grade. That's a lot of numbers, but they are all written on the data sheets we have available.

There were 1600 boards (3370 board feet) obtained from the sawbolts. That means a lot of handling and is one reason why short lumber is not widely used. But the problem is not as bad as it seems. These short boards have 2.1 board feet per board, but standard NHLA graded yellow-poplar averages 6 to 7 board feet per board. The green short lumber was sticker-stacked right after sawing and the stack was maintained all the way through the handling, transportation, and drying. We made up 4-foot wide by 4-foot high packages using 1/2-inch oak stickers on 2-foot centers. Then we bound the stacks with 1/2-inch wide polypropylene strapping. As

the stacks dried and shrunk, this strapping was retightened to keep the stack intact during forklift handling. That's how we beat the handling problem.

The stickered stacks of green boards were put into a forced-air dryer. This dryer has fans for air circulation, heating coils, but no humidity control. Cuppett has written about this dryer and its use.[1/] The heat control was set at 85°F and was not changed during the drying. Temperatures approached but did not reach 75°F as the drying was done in March and the weather was cold. Air velocity through the stacks was from 200-300FPM. The drying lasted 17 days during which the average moisture content fell from 110 to 12 percent. Drying degrade was minimal, mainly cupping of pith centered boards. After forced-air drying, the straps were re-tightened and the stacks were moved to a regular dry kiln. We used 175°F dry bulb and 120°F wet bulb for 3 days followed by 8 hours conditioning. The final moisture content was 5 percent and the condition of the short lumber was very good.

Now that we had made the kiln dried short lumber, we began the second half of the work: how to use short lumber in the furniture plant. Interior parts were chosen as the furniture product to be made. Interior parts are those structural pieces hidden from view. Because their primary function is strength, some defects can be permitted within the pieces but not at the ends. For this furniture line, all interior parts are made to the same thickness and width, but not to the same lengths. The rough size of the interior parts we made was 1 inch thick by 1-11/16 inches wide with the lengths ranging from 73 to 13 inches.

Ed Lucas and Phil Araman from our Lab in Princeton, studied interior parts manufacturing in cooperation with the Drexel-Heritage Furnishings Company. They tried a number of ways of making interior parts using different grades of yellow poplar lumber. They found that for a given lumber grade that yields were always the same no matter what method was used. So they chose a method that could be the most easily automated and worked out a balanced flow rough mill. In this rough mill the lumber is skip planed, gang ripped, and the resulting strips are defected. The random length rough interior parts are cut to the desired length on a "longest first" basis. Because there are a lot of short interior parts needed, this longest first technique is very efficient. Publications are available that explain this work.[2/3/]

[1/] Cuppett, Donald G. and Edward P. Craft. Low-temperature forced-air drying of Appalachian hardwoods. 1975. Research Paper NE-328.

[2/] Lucas, Edwin L. and Philip A. Araman. Manufacturing interior furniture parts: a new look at an old problem. 1975. Research Paper NE-334.

[3/] Araman, Philip A. and Edwin L. Lucas. An automated rough mill for the production of interior furniture parts. 1975. Research Paper NE-335.

Drexel-Heritage built an interior parts plant in Whittier, North Carolina, based on this Forest Service work. Much innovative machinery and design went into this plant. The most unique machine is the Optymiser made by Black Clawson. Defecting and cutting to the longest length first between defects is all done automatically in the Optymiser. This is an excellent rough mill in which the wood is not handled as it proceeds through from rough lumber to the finished interior part. This plant was written up in the November and December 1975 issues of Woodworking and Furniture Digest. Reprints are available from our Lab in Princeton.

We marked all 1600 boards to see what the yield of 1-11/16-inch wide strips would be. Two strips were obtained from the 4-inch wide boards at a 10 percent waste. Three strips were obtained from the 6-inch wide boards at a 12 percent waste. This was an overall 10.2 percent waste factor. Then we marked all the defect crosscuts on the strips. We tallied the yield of random length strips from 13 inches minimum to 72 inches maximum. Defecting caused an additiona 13.8 percent waste. But 60 percent of the strips, by surface area, was found in the 72 inch length while only 13 percent of the required interior parts area was at 72 inch length. When we cut for the required lengths of interior parts by the longest length first method, another 4 percent waste was encountered. So from this laboratory work, we calculated a 72 percent yield which we thought was quite respectable for short lumber.

We selected every other board, 800 out of the 1600, to bring down to the Drexel plant at Whittier for a mill trial. A typical interior parts order was set up with nine parts lengths ranging from 14 inches through 71 inches long with the quantities required for each length. A short test run was made and a 71 percent yield was found. A longer run was then made and a 73 percent yield was found. At the start of the trial, the Drexel folks thought that using short lumber would slow down production. Our short lumber boards were narrow and the gang ripsaw might not be able to make enough strips for the rest of the line. This was not the case as production was at the normal rate through the Optymizer crosscut saw. We were very pleased with the short lumber in this mill trial.

I would like to repeat the three results from this work. The first result was that the random length yellow-poplar pulpwood was an adequate supply for the sawbolts. Bucking out sawbolts was not difficult or time consuming. A slasher saw mounted at the infeed end of a chip harvester would do a good job bucking out such sawbolts. The second result was that the pallet part sawmill was a strange but effective way to reduce the sawbolts to short lumber. The sawing was fast, accurate, and inexpensive. The third result was that while this short lumber looked funny, it was an adequate substitute for No. 2A Common yellow-poplar lumber at this plant. The handling, drying, and use of these small boards presented no problems that were not amenable to solution.

So there is one example where short logs were used to make short lumber which was used to make furniture parts. We will continue to work in this field and I am sure that at future Hardwood Research Council meetings you will hear of more success stories like this.

FURNITURE PARTS FROM PULPWOOD - A PLANT THAT DID IT

A talk by Hugh Reynolds, Engineer, USDA Forest Service, Princeton, West Virginia.
Given at the IV Annual Symposium of the Hardwood Research Council at High Hampton, North Carolina, on April 30, 1976.

Pertinent Data

Bolts

205 bolts 6 feet 3 inches long, 6-12 inches in diameter
570 cubic feet volume, 2,919 board feet scale, gross
8.4 inch average diameter
(Bolt volume by Smalian's formula, two diameter measurements each end)
(Bolt scale by 1/4-inch International rule to the nearest board foot)

Boards

1,604 boards: 1,442 1x4, 162 1x6, 72 inches long
Thickness: 1 inch nominal, 1-1/16 inch actual (green)
Width: 4 inch nominal, 3.75 inch actual (green)
6 inch nominal, 5.75 inch actual (green)
Scale: 1"x4"x6' = 2 board feet 1"x6"x6' = 3 board feet
281 cubic feet board volume (green)
49 percent volumetric recovery (281 ÷ 570 = 0.49)
5.9 board feet/cubic foot LRF (3370 ÷ 570 = 5.91)
15 percent overrun ((3370 - 2919) ÷ 2919 = 0.15)
13 percent No. 1 Common, 71 percent No. 2 Common, 12 percent No. 3A Common, 4 percent less than No. 3A (by NHLA grade rules with length restrictions waived)

Interior Parts Yield from Kiln Dried Boards

Lab Test

After gang ripping to 1-11/16" x6':	89.8% board area	10.2% waste (includes shrinkage)
After defecting:	76.0% board area	13.8% waste
After cutting to required lengths:	72.0% board area	4.0% waste

Requirements by length and piece count:

72" - 5%	37" - 6%	24" - 17%	15" - 32%
62" - 7%	36" - 8%	22" - 3%	13" - 3%
56" - 2%	30" - 3%	16" - 14%	

Plant Test

First trial: 71% board area yield (includes shrinkage)
Second trial: 73% board area yield (includes shrinkage)
Requirements by length and piece count:

70-7/8" - 7%	36-1/2" - 14%	21" - 3%
60-7/8" - 7%	30-1/8" - 3%	15-15/16" - 45%
55" - 2%	23" - 16%	13-13/16" - 3%

A LOW DENSITY FIBERBOARD FROM TOTAL TREE CHIPS FOR THE FURNITURE INDUSTRY[1]

M. W. Kelly and R. G. Pearson

The quantity of medium density fiberboard used in furniture production is rapidly increasing due to the significant advantages of this material over particleboard and also due to the limited supply of inexpensive, high-quality hardwood lumber. The particle configuration in medium density fiberboard (MDF) is individual wood fibers and fiber bundles in which the macroscopic wood structure has been destroyed by pressurized refining of wood particles or chips. The small fiber bundles form a more homogeneous panel product with smaller interparticle voids than is common in particleboard. The larger interparticle voids in particleboard and the non-uniform density distribution in the thickness direction result in edge finishing difficulties. Lumber or vinyl edge-banding of exposed particleboard edges in furniture construction is commonly used to circumvent this problem. The porous surfaces of most particleboard also requires additional filling steps in the finishing operation.

The superior uniformity of MDF results in better finishing characteristics, tighter panel edges, and a lower vertical density gradient; consequently, fewer finishing difficulties are encountered and edge banding is also not required. These advantages of MDF allow it to command a significant price premium over particleboard for many furniture components.

Fiberboard panels offer an excellent potential for increasing the economic value of scrubby, crooked, and low quality hardwood fiber. Poor or non-existent forest management in the past has allowed hardwoods to invade sites more suitable for other species; one half of the 108 billion cubic feet of hardwood growing in the South is on sites more suitable for pine and 50 percent of this material is in trees less than 11 inches dbh (3). Also, the hardwood sites are typically small and privately owned tracts on which no forest management has been practiced, resulting in less than optimum growth of high quality hardwoods. Consequently, a large portion of the hardwood fiber on hardwood sites is found in cull trees which have no future value as sawn lumber.

Due to the high cost of their removal, these small, non-mercantile hardwoods on both hardwood and pine sites have reduced the incentive for the landowner to institute proper forest management. Anderson (2) has recently discussed the economics of converting pine sites with undesirable hardwoods into more productive, managed pine forests. The most economical conversion would be by utilizing the fiber in a product from which a portion of the conversion cost could be recovered. Present attempts to convert poorly managed hardwood sites to productive, well-managed, hardwood forests would receive additional impetus if an economic value could be developed for the presently cull material.

---

[1]The authors wish to acknowledge the financial assistance of the Southeastern Forest Experiment Station, Asheville, N. C. and the North Carolina Agricultural Experiment Station, North Carolina State University, Raleigh, N. C.

The in-woods total tree chipper offers a harvesting method for removal of low-quality hardwoods from both hardwood and pine sites. The site preparation required for reforestation after total tree chipping is minimal and even small forest tracts can be harvested economically due to the portability of the chipper. The high dirt and bark content of the chips from small trees limits the usefulness of large fractions of this material in paper products. Research efforts are continuing to develop dirt removal techniques which will allow wider use of total tree chips in products requiring dirt-free furnish. However, total tree hardwood chips may be more suitable for medium and low density fiberboards where small bark particles will not adversely influence the appearance or utility of the product.

Medium density fiberboard is presently used in many applications where a lower density panel product would be suitable with adequate edge tightness and surface smoothness. Also, additional applications may be developed for this low density material in which its lighter weight and reduced production costs would be advantageous. One potential application of low density fiberboard is in a composite with the fiberboard as core and inexpensive pine veneers for the surfaces. Depending upon the strength properties of this composite, it may find service in lightly stressed structural members in furniture construction, thus reducing the required amount of solid hardwood. Consequently, the physical and mechanical properties of low density fiberboard, and composites with low density fiberboard cores, are of importance and formed the subject of this study.

Objective

The objective of this study was to determine the physical and mechanical properties for fiberboards of three different densities produced from total tree hardwood chips. Also, the properties of composites with low density fiberboard cores and southern pine veneer skins were studied to determine the feasibility of this construction for structural furniture components.

Experimental Procedure

Total tree hardwood chips were obtained from an in-woods chipping operation located in the upper coastal plain of northern North Carolina. The chips were obtained on a dry day in December; therefore, the leaf and dirt content may be lower than could reasonably be expected from typical chipping operations on wet terrain in the summer. The trees were from 5 to 10 inches in diameter and consisted predominately of oak but sweetgum, maple, and other hardwoods were also present.

The chips were screened to remove both the oversized material and the fines. Only material passing a screen with holes 1.5 inches square and retained on a screen with holes 0.25 inch square was used in this study. The fine fraction passing the small screen consisted of predominately bark particles; many pencil-size twigs and sticks passed lengthwise through the upper screen and were included in the furnish. These twigs and sticks contributed a relatively large bark fraction but no difficulties were evident in processing this material.

It was desired to simulate medium density fiberboard production as closely as possible in making the fiberboard panels for this study. Consequently, the screened chips were sent to C. E. Equipment Development Laboratory in Springfield, Ohio and refined on a double disc pressurized refiner. A dwell time of 5 minutes in the digester at 80 psi steam pressure followed by pressurized refining with a plate setting of 0.070 inch were the conditions used for refining the chips. The refined fibers were shipped to the pilot plant of Miller Hofft, Inc., Richmond, Virginia, where they were dried and the fiberboards were produced.

A total of 63 experimental boards were made, all with a two-component melamine-fortified urea-formaldehyde adhesive content of 8 percent (resin solids on OD wood weight). One percent wax solids (based on OD wood weight) was also added to the furnish. Fiber mats were vacuum-felted, pressed to thickness, and cured in a hot press equipped with a RF generator. Platen temperature of the hot press was 300°F and press time varied with thickness and density of the panel.

The fiberboard panels were trimmed and sanded to uniform thickness with a wide-belt sander. Composite 3-ply panels were formed by bonding 1/8 and 1/4 inch southern pine veneer to most of the fiberboard panels as shown in the experimental design of Table 1. The veneer was tightly peeled and dried in the Hodges Wood Products Laboratory at North Carolina State University. A urea-formaldehyde liquid laminating adhesive was used at a spread level of 35 lbs./MSGL, with a press temperature of 270°F, and press times as recommended by the supplier for the various veneer and core thicknesses. The low density fiberboard cores were easily compressed during pressing; consequently, the distance between the press platens was closely monitored to prevent excessive core compression.

Table 1. Composite Construction And Number Of Test Panels

Fiberboard Core			
Nominal Density (pcf)	Nominal Thickness (inch)	Veneer Thickness (inch)	Number of Panels
25	3/8	0	1
	3/8	1/8	5
	3/8	1/4	5
	3/4	0	1
	3/4	1/8	5
	3/4	1/4	5
35	3/8	0	1
	3/8	1/8	5
	3/8	1/4	5
	3/4	0	1
	3/4	1/8	5
	3/4	1/4	5
42	3/4	0	1

Panel Testing

All tests were conducted in accordance with ASTM Standard Method D 1037-72 (1), except where noted. Tests for which the grain direction of the veneer was expected to influence the results were conducted both parallel and perpendicular to the veneer grain direction. Due to the limited panel size, the span for the static bending test perpendicular to the face veneer for the two thickest composites was 21 inches instead of 24 and 30 inches as specified in D 1037-72.

Results And Discussion

The test results are presented in Tables 2 and 3 and Figures 3 to 9. The number of specimens tested for each panel is noted in the tables; due to the limited sample size for most tests, no statistical analysis was attempted. Figure 1 is the edge appearance of all composite combinations showing the relative surface-core thickness. Figure 2 illustrates the typical surface of a 3/4 inch thick, 35 pounds per cubic feet (PCF) fiberboard (OD volume and weight). The surfaces of all 35 and 42 PCF boards

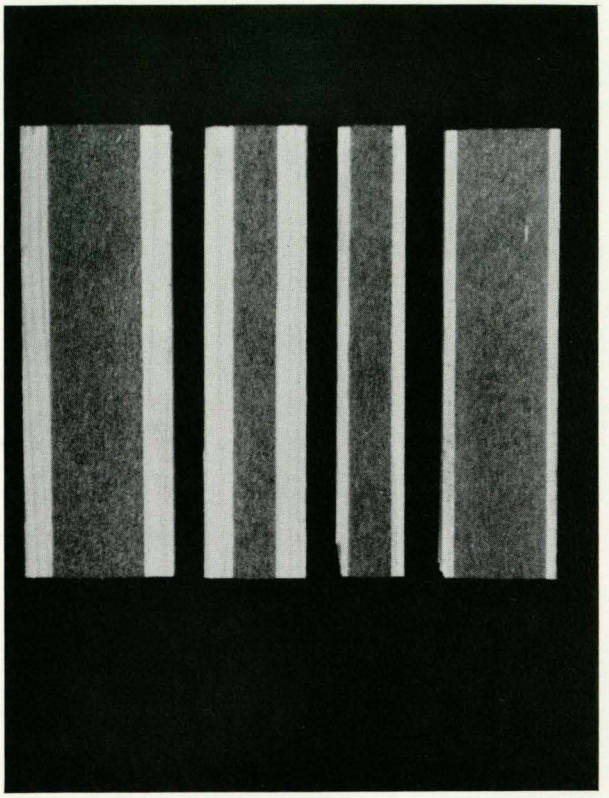


Figure 1. Edge appearance of all composite combinations showing the relative thickness of the fiberboard cores and southern pine veneers.

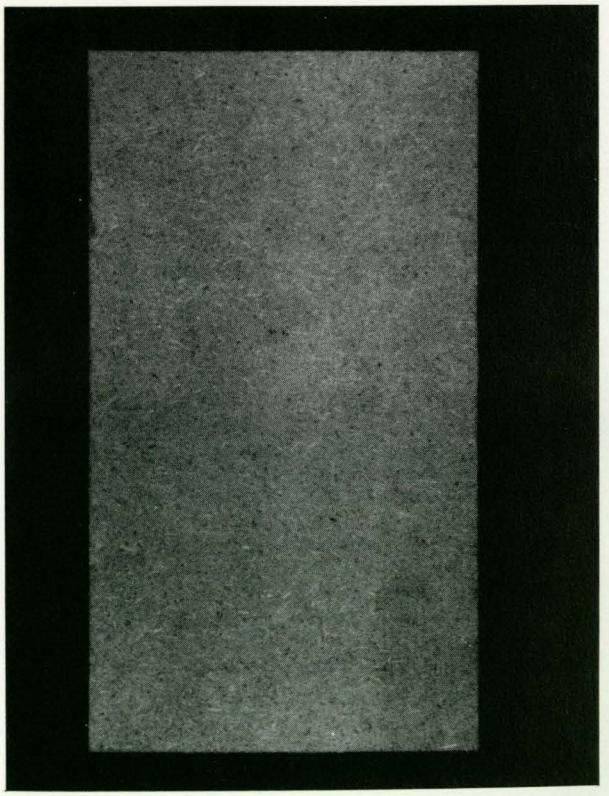


Figure 2. Typical sanded surface of a 35 pcf 3/4 inch thick fiberboard produced from total tree hardwood chips.

Table 2. Test Results For Fiberboard And Composites Of 25 PCF Nominal Density[a]

Nominal Fiberboard Density (pcf)	25					
Fiberboard Thickness (in.)	3/8			3/4		
Surface Veneer Thickness (in.)	0	1/8	1/4	0	1/8	1/4
Density At Test (pcf) (OD Weight, Test Volume)	26.8	-	-	28.0	-	-
Moisture Content (%)	7.8	8.3	7.9	7.4	8.0	8.2
Modulus of Rupture (psi)	892.5(2)	// 7210(5) ⊥ 929(5)	// 6750(5) ⊥ 509(5)	1330(2)	// 4030(5) ⊥ 746(5)	// 3630(5) ⊥ 571(5)
Modulus of Elasticity ($X10^6$ psi)	0.114(2)	// 1.440(5) ⊥ 0.133(5)	// 1.470(5) ⊥ 0.078(5)	0.139(2)	// 0.904(5) ⊥ 0.120(5)	// 1.390(5) ⊥ 0.084(5)
Internal Bond (psi)	34.0(3)	49.6(19)	48.2(20)	33.9(3)	26.1(20)	26.3(18)
Direct Nail Withdrawal (lbs./in. of penetration)	22.0(1)	121.6(4)	163.9(5)	76.6(1)	89.0(5)	119.8(5)
24 Hours Water Soak Water Absorption (%)	137.4(1)	23.1(5)	34.3(5)	102.3(1)	20.1(5)	23.8(5)
Thickness Swell (%)	13.6(1)	4.0(5)	3.8(5)	12.2(1)	2.6(5)	2.8(5)
Linear Expansion (%) 50-90% R.H. Exposure	0.337(2)	// 0.078(5) ⊥ 0.742(5)	// 0.067(5) ⊥ 1.048(5)	0.291(2)	// 0.073(5) ⊥ 0.557(5)	// 0.078(5) ⊥ 0.675(5)
Lateral Nail (lbs.) 1/2 inch from edge	80(2)	347(9)	441(10)	244(2)	411(10)	422(10)
Interlaminar Shear (psi)	-	132(5)	106(5)	-	78(5)	82(5)
Edgewise Shear (psi)	447(2)	881(10)	644(10)	538(1)	499(8)	495(10)

[a]Numbers in parentheses indicate number of specimens tested.

Table 3. Test Results For Fiberboard And Composites Of 35 And 42 PCF Nominal Density[a]

Nominal Fiberboard Density (pcf)	35						42
Fiberboard Thickness (in.)	3/8			3/4			3/4
Surface Veneer Thickness (in.)	0	1/8	1/4	0	1/8	1/4	-
Density At Test (pcf) (OD Weight, Test Volume)	34.8	-	-	35.6	-	-	43.4
Moisture Content (%)	7.2	8.0	8.1	7.6	7.8	8.0	7.3
Modulus of Rupture (psi)	2355(2)	// 11260(5) ⊥ 1279(5)	// 10400(5) ⊥ 693(5)	2375(2)	// 8150(5) ⊥ 1358(5)	// 7560(5) ⊥ 913(5)	4470(2)
Modulus of Elasticity ($X10^6$ psi)	0.226(2)	// 1.610(5) ⊥ 0.154(5)	// 1.653(5) ⊥ 0.074(5)	0.254(2)	// 1.241(5) ⊥ 0.170(5)	// 1.429(5) ⊥ 0.104(5)	0.436(2)
Internal Bond (psi)	77.0(3)	111.1(18)	104.8(20)	73.5(3)	53.8(18)	51.5(19)	93.5(3)
Direct Nail Withdrawal (lbs./in. of penetration)	102.1(1)	240.7(5)	232.4(5)	142.5(1)	172.6(5)	197.7(5)	210.0(1)
24 Hours Water Soak Water Absorption (%)	74.9(1)	19.2(5)	25.5(5)	55.0(1)	14.8(5)	24.2(5)	40.6(1)
Thickness Swell (%)	12.4(1)	3.0(5)	3.4(5)	10.1(1)	2.4(5)	3.0(5)	9.7(1)
Linear Expansion (%) 50-90% R.H. Exposure	0.329(2)	// 0.097(5) ⊥ 0.620(5)	// 0.080(5) ⊥ 0.680(5)	0.271(2)	// 0.100(5) ⊥ 0.346(5)	// 0.0867(5) ⊥ 0.564(5)	0.258(2)
Lateral Nail (lbs.) 1/2 inch from edge	144(2)	556(10)	578(10)	499(2)	598(10)	566(10)	602(2)
Interlaminar Shear (psi)	-	240(5)	203(5)	-	157(5)	164(5)	-
Edgewise Shear (psi)	1132(1)	1148(10)	769(10)	945(2)	767(10)	677(10)	1109(2)

[a]Numbers in parentheses indicate number of specimens tested.

were excellent and showed little evidence of bark particles, although the lower surfaces had a slightly higher bark fraction. The 25 PCF fiberboards (OD volume and weight) had a porous surface which was relatively soft.

The limited test results for the 42 PCF fiberboard (OD volume and weight) indicate an excellent potential exists for producing acceptable medium density fiberboard from total tree hardwood chips. Table 4 compares the physical and mechanical properties of this type of panel with those of two commercial medium density fiberboards of similar density, as reported by Superfesky and Lewis (4). The only properties of the test board which are significantly lower than those of the commercial boards are the water absorption and thickness swelling, as determined by the 24 hour water soak test, and the internal bond strength. The reason for the high water absorption and thickness swelling is not immediately evident, although it is most likely due to the bark fraction. One feasible explanation may be the creation of micro-voids within the bark particles as the result of tensile failure when the fiberboard swells in thickness. Water could then enter these capillaries and voids, significantly increasing the water absorption values. The high water absorption and thickness swelling evident with the 24 hour water soak test should not, by itself, eliminate total tree chips as a source for MDF. This test is a rapid and convenient method for estimating the durability and resistance of a wood-base material to liquid water. Although this test has some merit for products in which periodic exposure to liquid water could reasonably be expected, such as particleboard for underlayment in house construction, it has little application for material used in furniture construction.

Table 4. Comparison Of Two Commercial Medium Density Fiberboards (From Superfesky And Lewis (4)) With Medium Density Fiberboard From Total Tree Chips

Property	Commercial MDF	MDF From Total Tree Chips
Density[1] (pcf)	41.2 - 42.4	43.4
Moisture Content[2] (%)	6.6 - 7.8	7.3
Modulus of Rupture (psi)	4670 - 5200	4470
Modulus of Elasticity ($X10^3$ psi)	485 - 519	436
Internal Bond (psi)	133 - 140	94
24 Hour Water Soak		
Absorption (%)	10.3 - 12.5	40.6
Thickness Swelling (%)	2.8 - 3.2	9.7
Linear Expansion (%)	0.36 - 0.42[3]	0.26[4]

[1] Based on OD weight and test volume

[2] At equilibrium of 73°F and 50 percent relative humidity

[3] 30-90 percent relative humidity change

[4] 50-90 percent relative humidity change

The low tensile strength of bark may also account for the reduced internal bonds of this total tree based fiberboard. Increased adhesive content or other processing

adjustments may be required to improve the internal bond strength for given applications. However, an internal bond of 90 psi is higher than the present Commercial Standard for particleboard at a comparable density (5). Unfortunately, no acceptable standard for MDF presently exists but it is unlikely that a MDF standard, when finally developed, will specify internal bonds above 90 psi for a product within this density range. Medium density fiberboard from total tree chips, therefore, should be considered as a potential material for furniture construction.

Figures 3 and 9 graphically present the results of selected properties for all fiberboards and composites tested in this study. The 25 and 35 PCF nominal density fiberboards (OD volume and weight) had lower properties than the 42 PCF fiberboard in all cases, although the linear expansion of the lower density fiberboards was comparable to the standard product. The composites, with pine veneer surfaces and fiberboard cores, had substantially improved properties when tested parallel to the veneer grain direction as opposed to those tested perpendicular to the veneer grain. The modulus of elasticity (Figure 3) and the modulus of rupture (Figure 4) were lower for the composites tested perpendicular to the surface veneer grain direction than the corresponding values for the unveneered fiberboard. This is a reflection of the increased specimen depth since the tensile strength of the lower veneer is negligible and contributes nothing to the bending strength of the composite.

The linear expansion (Figure 5) of the composites between moisture equilibrium at 50 and 90 percent relative humidity also reflects the large dimensional changes of wood in the transverse direction as opposed to the small swelling in the longitudinal axis. As the density and thickness of the fiberboard core increased at constant veneer thickness, the core offered more resistance to the swelling of the surface; consequently, the linear expansion of the composite decreased.

The lateral nail (Figure 6) and nail withdrawal (Figure 7) results for the composites with the 35 PCF nominal density fiberboard were comparable to the results obtained with the 42 PCF fiberboard. Nailing is not a satisfactory method of fastening MDF and, since the composite results offer no improvement, nailing is not a potentially satisfactory method of fastening or joining this composite.

The internal bonds (Figure 8) for the composites were significantly different than expected. Theoretically, the internal bond of the composite would be equal to that of the fiberboard core. However, such was not the observed result. The unveneered fiberboards of equal densities had essentially a constant internal bond, regardless of fiberboard thickness. The internal bond, as expected, increased as the nominal fiberboard density increased from 25 to 35 PCF. However, the internal bond of the composites, instead of being equal to the unveneered fiberboard, was lower for the thicker fiberboard cores and significantly higher for the thinner fiberboard cores. This effect was present regardless of the veneer thickness. Since internal bond failures for all composites and fiberboards occurred horizontally at the specimen midplane, the thin fiberboard was strengthened and the thick fiberboard weakened by gluing the veneer surfaces to the fiberboards. One possible explanation for this unexpected result is that different temperature levels were obtained at the centerline of the two fiberboard thicknesses during the laminating operation. A urea-formaldehyde liquid adhesive was the laminating adhesive and recommended press time, press temperature, and spread levels supplied by the adhesive manufacturer were observed. However, the additional one minute press time recommended for the 3/4 inch fiberboard core over the press time for the 3/8 inch core does not appear to be sufficient time for the center temperature to reach the same level with the 3/4 inch core. The improved internal bond for the composites with the 3/8 inch fiberboard core could be the result of an additional curing reaction of the adhesive used in the original fiberboard manufacture. The additional interfiber bonding resulting from this curing should improve the internal bond; hence, the internal bond of the composites with the thin fiberboard core would be as observed.

Figure 3. Modulus of elasticity for fiberboards and composites, determined both parallel and perpendicular to the face veneer grain direction for the composites.

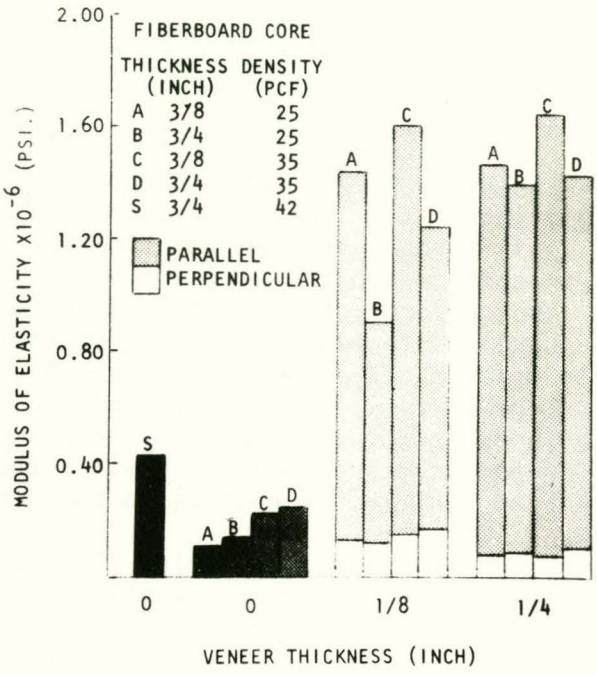


Figure 4. Modulus of rupture for fiberboards and composites, determined both parallel and perpendicular to the face veneer grain direction for the composites.

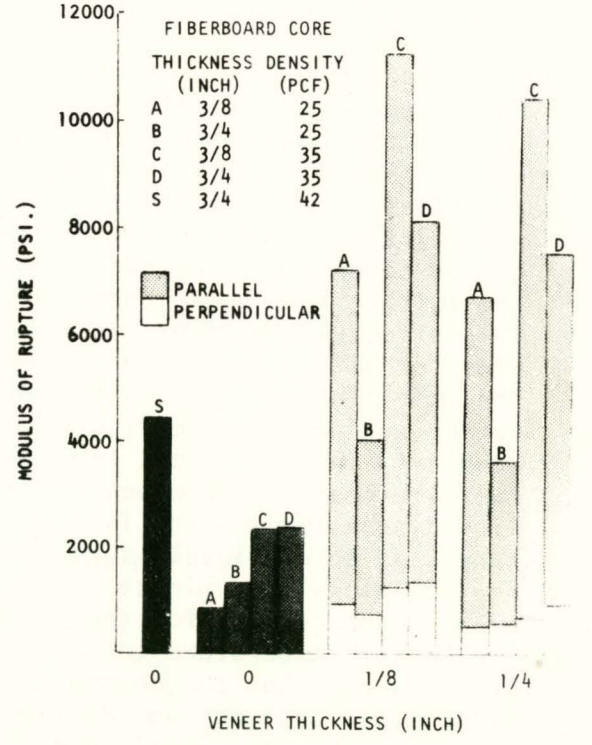


Figure 5. Linear expansion of fiberboards and composites from equilibrium at 50 percent to equilibrium at 90 percent relative humidity, determined both parallel and perpendicular to the face veneer grain direction for the composites.

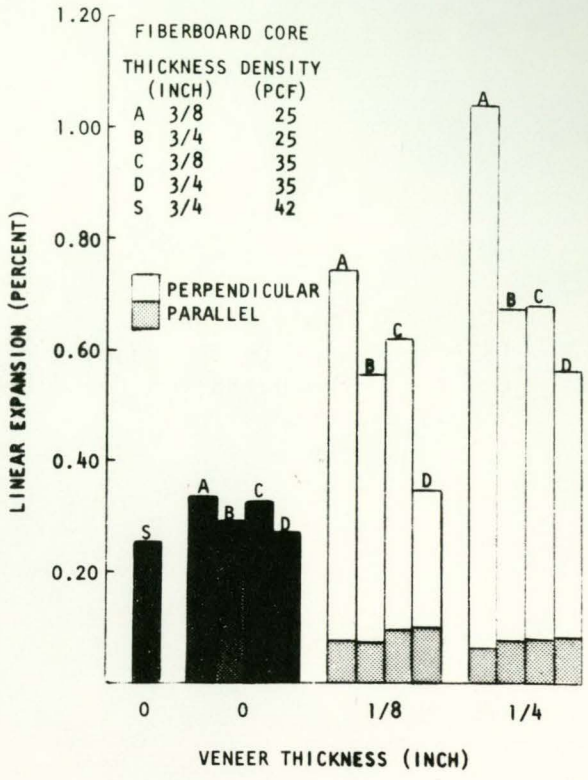
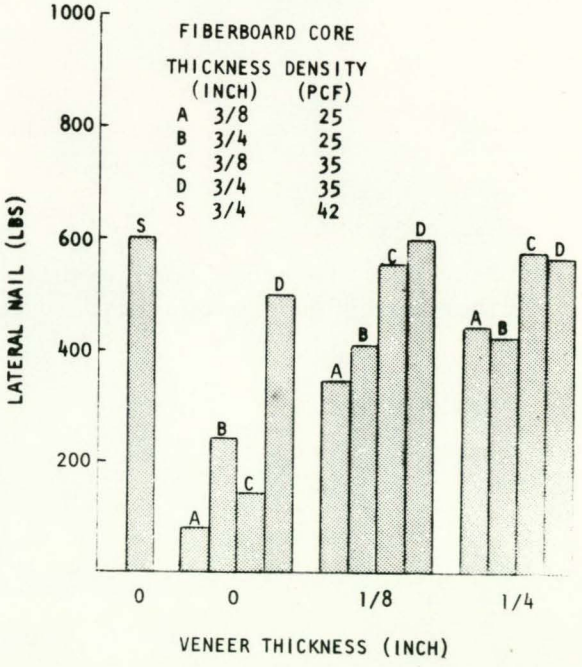


Figure 6. Lateral nail resistance for fiberboards and composites, with the nail 1/2 inch from the panel edge. Nail resistance for the composites was determined across the grain of the veneers.



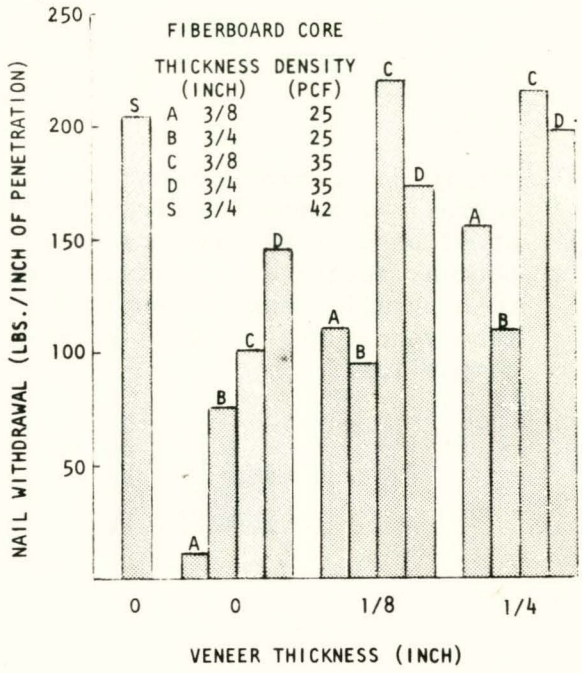


Figure 7. Nail withdrawal resistance (perpendicular to the panel surface) per inch of penetration for fiberboards and composites.

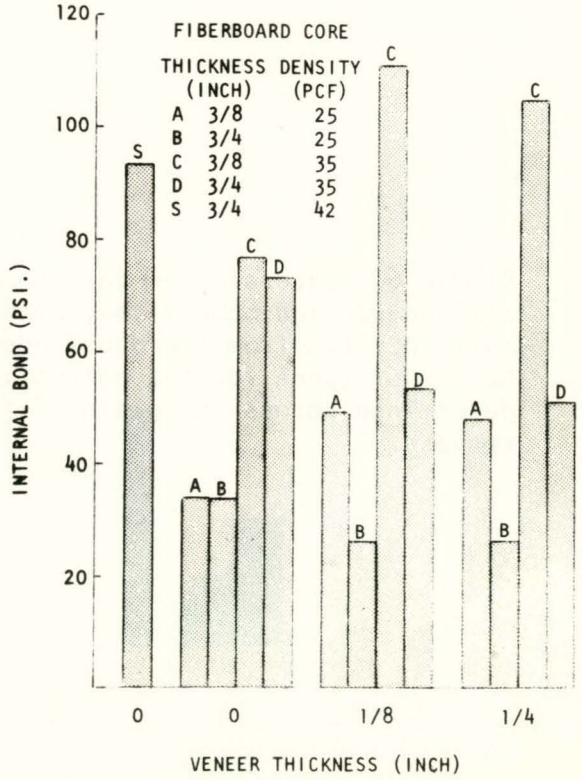


Figure 8. Internal bond results for fiberboards and composites.

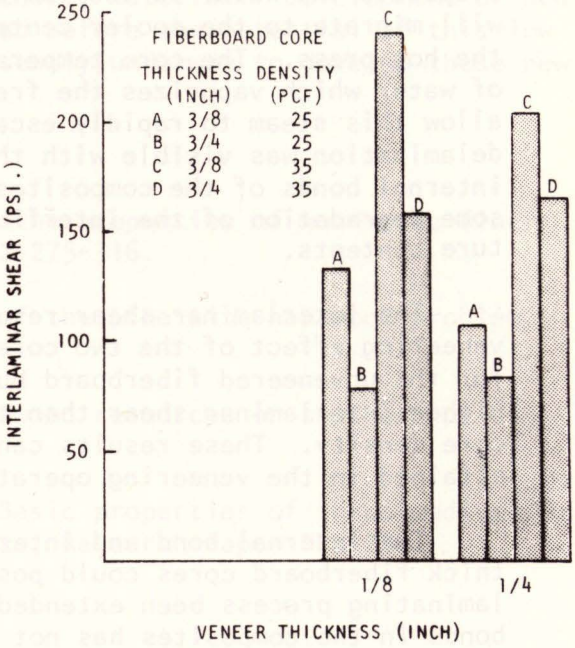


Figure 9. Interlaminar shear for the composites.

The reduced internal bonds for the composites with the thick fiberboard core can also be attributed to the laminating process. However, in this case the temperature at the fiberboard core not only failed to reach a sufficient level to cure the fiberboard adhesive, but it was not sufficiently high for the time required to adequately evaporate the water in the laminating adhesive. The water in the laminating adhesive will migrate to the cooler center when the composite is heated between the platens of the hot press. The core temperature will eventually increase above the boiling point of water which vaporizes the free water in the core. Premature press opening will allow this steam to rapidly escape, resulting in delamination in severe cases. No delamination was visible with the composites produced in this study but the reduced internal bonds of the composites with the 3/4 inch fiberboard cores indicate that some degradation of the interfiber bonds did occur, most likely due to high core moisture contents.

The interlaminar shear results of the composites, Figure 9, also illustrates the veneering effect of the two core thicknesses. No interlaminar shear test was conducted for the unveneered fiberboard but the composites with the 3/8 inch core always had higher interlaminar shear than the composites with the 3/4 inch core, regardless of core density. These results can also be attributed to the different core temperatures attained in the veneering operation as discussed above.

The internal bond and interlaminar shear results for the composites with the thick fiberboard cores could possibly have been improved had the press time of the laminating process been extended. The proposed reason for the change in internal bonds in the composites has not been investigated due to the lack of material but, assuming this theory is valid, more attention should be focused on insuring that press times are sufficiently long to remove the free water and not limited solely to the distance from the surface to the deepest glueline. Producers and users of laminated particleboard and medium density fiberboard should be aware of potential internal bond and interlaminar shear reductions if conservative press cycles are not observed.

Conclusions

Medium density fiberboard can be produced from total tree hardwood chips without encountering significant processing difficulties. However, economical methods of satisfactory dirt removal are required before widespread use of this material is realized. With the exception of large water absorption and thickness swelling in the water soak test, all physical and mechanical properties are comparable to the presently available MDF.

Low density fiberboard can also be produced from total tree hardwood chips but the potential of the 25 PCF (OD volume and weight) fiberboard for furniture construction appears to be extremely limited. However, the properties of the 35 PCF (OD volume and weight) fiberboards produced in this study from total tree hardwood chips do appear to be sufficient to warrant further study. These fiberboards had smooth, uniform surfaces and tight, homogeneous edges. The mechanical and physical test results indicate that this fiberboard has an excellent potential as a substrate for grain printing, wood veneering, and vinyl and high density overlays. This material, with the above finishes, could be used in many non-structural furniture applications, such as tops, sides, and drawers.

The low density fiberboards can also be used as core material for lightweight wood-based composites with wood veneer surfaces. The composites made in this study, with low density fiberboard cores and southern pine veneer surfaces, appeared to have sufficient strength for some lightly stressed structural components in furniture, especially in applications requiring high bending strength.

Presently, the most severe limitation to widespread use of this low density fiberboard, or the composite with this fiberboard as core, is the lack of adequate fastening methods to attach this material to other furniture components. Unfortunately, the traditional furniture fastening methods of dowels, screws, and staples are not likely to be satisfactory for this low density material. Development of new fastening techniques and new fasteners is required before the potential of this low density fiberboard is realized. Research is presently underway to develop these new fasteners and fastening techniques.

LITERATURE CITED

1. ASTM. 1975. Standard methods of evaluating the properties of wood-base fiber and panel materials. D 1037-72, Part 22:275-316.

2. Anderson, W. C. 1974. An economist's view of the pine-site hardwood problem. Forest Prod. J. 24(4):14-16.

3. Murphy, P. A., and Knight, H. A. 1974. Hardwood resources on southern pine sites. Forest Prod. J. 24(7):13-16.

4. Superfesky, M. J., and Lewis, W. C. 1974. Basic properties of three medium-density hardboards. USDA, Forest Service, Research Paper FPL 238.

New Methods of Drying Hardwood Lumber

by

C. Skaar

April, 1976

Abstract

Three unconventional methods for drying hardwood lumber are discussed. These are, radio frequency or dielectric drying, controlled solar energy drying, and acoustical-emission defect controlled drying. Radio-frequency drying is probably limited to specific high quality products because of technological and economic constraints. Controlled solar energy drying will become more important as the technology develops and as fossil fuels become more expensive. Acoustical-emission controlled drying shows intrinsic promise as a method for controlling drying of hardwoods based on reducing defects to a minimum consistent with maximum rate of drying.

I have been assigned to speak on the topic "New Drying Processes for Hardwoods". In order to view this topic from the proper perspective it is worthwhile quoting from Harry D. Tiemann who might be called the "father" of modern kiln-drying techniques. In Mr. Tiemann's 1958 FPRS lecture on the highlights leading up to modern kiln drying (Tiemann, 1959) he included a topic which he designated as "brainstorms on drying methods". Here he listed 30 unconventional methods which have been proposed for drying lumber, and all of which he investigated to some extent. He stated "As to methods of drying, almost every conceivable operation has been thought of and tried--the majority have petered out or proved impracticable. Failure in a commercial process, however, does not necessarily imply that the principles involved were wrong. Some were technically absurd, but others contained ideas that were impractical for economic reasons".

I don't intend to speak to these 30 methods which Tiemann listed, but will limit myself to three, the first of which is mentioned by Tiemann. These are, radio-frequency or dielectric drying, controlled solar drying, and acoustic-controlled drying in which acoustic emissions associated with defect formation are used to control the drying process.

Before proceeding to a discussion of the details of the three drying methods, it is best to review quickly the broader aspects of the problem. Wood is formed in the living tree under conditions where the individual cells are essentially saturated with water, including both the cell walls and the cell cavities. One or more years after they are formed, the cell cavities generally lose some of their water and are partially dry. The water remaining in the cell cavities is called "free" water since it is usually easy to remove compared with the "bound" water which is contained in the wood cell walls. When green wood, which contains both free and bound water, is exposed to ordinary atmospheric conditions, it will eventually lose all of its free water from the cell cavities and perhaps half of the bound water before becoming "seasoned". This means that it is at moisture equilibrium with the atmosphere around it. This moisture content, corresponding to the air-dry condition, is normally about 15 percent of the "bone-dry" weight of the wood. This is about half of the fiber-saturation point of about 30 percent which represents the saturated moisture content of the cell wall in green wood.

Removal of free water from the cell cavities of wood is usually accomplished without shrinkage except for the case of "collapse", a phenomenon in which the cell walls of individual cells or groups of water-logged cells literally collapse into their cell cavities as water is removed from them (see Figure 1). Shrinkage always occurs, however, when any portion of the wood dries below the fiber-saturation point (FSP), and it is during this stage of drying that surface checking occurs. If surface checking could be minimized or eliminated much of the degradation during drying, particularly that of high quality hardwood lumber, would be reduced.

A. Radio-Frequency Drying

The drying of lumber by radio-frequency (RF) heating offers certain intrinsic advantages over conventional kiln-drying methods. First, the energy for drying is generated within the lumber such that the temperature decreases from the center to the surface, in contrast to the standard drying

methods in which heat is conducted from the surface to the interior. This means that there need be no steep moisture gradient, particularly near the surface where drying defects generally occur. Both hydrostatic and vapor pressures are greater at the interior of the lumber than at the surface because of the inverse temperature gradient so that moisture will move to the surface even if the surface is somewhat wetter than the interior. The entire process tends toward maintaining a flat moisture gradient in the lumber because of the intrinsic fact that energy is absorbed by any part of the lumber in proportion to its localized moisture content. Therefore, the wetter parts of the wood tend to heat more rapidly than the drier portions thus driving moisture from the wetter to the drier wood.

Several factors, both technological and economic, have mitigated against the radio-frequency drying of lumber. One technological problem is the geometry of electrodes required to apply power uniformly to the lumber in an installation of commercial size. There is the related problem of maintaining efficient delivery of power to the load as it dries and/or heats up, since the electrical characteristics of the wood change with change in moisture content and temperature. Another potential problem is the presence of wet impermeable regions in the lumber which encourage a buildup of steam pressure sufficient in some cases to rupture the wood. The economics of RF drying have also reduced its acceptability since it is more expensive than conventional drying equipment both in terms of initial and operating costs. It has been competitive in the case of certain specialized high-cost items for which its inherent advantages can be realized economically.

One of the potential uses of RF drying which might be investigated is to drive water out of green wood in liquid form so that the energy required to vaporize this water could be eliminated from the process. In this technique, the wood could be passed between RF electrodes which would heat the green lumber sufficiently to drive the liquid water to the surface. This liquid water could be scraped off the surface of the lumber as it passes beyond the RF electrodes. A series of passes could be made till most of the excess water was removed after which the lumber could be dried further by conventional methods. Figure 2 illustrates schematically how such a system might operate. It would be successful only for woods of high permeability and moisture content, such as southern yellow pine, for example.

B. Controlled Solar Energy Drying

The second drying method which we shall discuss has been labelled "controlled solar drying". There has been a renewed interest in the direct use of solar energy for supplementing man's needs since the cost of fossil fuels has increased so strikingly. Solar energy has been used to dry lumber and other materials since ancient times, because all air-drying or seasoning techniques rely on solar energy for evaporating the water. Furthermore, all energy obtained from fossil fuels was captured by plants in ages past and stored in chemical form. However, the kind of drying we are concerned with here is designated as controlled solar drying in order to emphasize that the energy is used in a controlled rather than haphazard manner as in normal air drying.

Solar energy has been advanced by some as a panacea for all of man's energy needs. This is true to the extent that all of our energy, except for nuclear energy, is derived, or has been derived from the sun. However, there

are two constraints to the direct use of controlled solar energy for drying lumber. One of these is the low intensity of solar energy and the second is its intermittent nature.

Controlled use of solar energy for drying lumber was first proposed in the United States by Dr. Farrington Daniels at a conference on "Fundamental research in wood drying" held in October, 1957, at the U. S. Forest Products Laboratory in Madison, Wisconsin, reported by Youngs (1959). The late Dr. Daniels was at that time director of the Solar Energy Laboratory of the Engineering Experiment Station at the University of Wisconsin. He later authored the book entitled "Direct use of the sun's energy" (1964), in which he pointed out the potentials, challenges, problems, and applications of solar energy for meeting man's energy needs, including applications in drying. As a direct result of Dr. Daniels' suggestions and interest, a program was initiated at the Forest Products Laboratory in Madison to explore the possibilities of using direct solar energy for the controlled drying of lumber. Many of the subsequent studies of controlled solar drying have been based on the experience of the U. S. Forest Products Laboratory as reported initially by Peck (1962).

As mentioned previously, solar energy is a low intensity energy source. Furthermore, its intensity varies with time of day, time of year, and also with latitude or distance from the equator. For the U. S. as a whole, the average intensity of solar radiation is about 1500 BTU/ft^2/day, or about 65 BTU/ft^2/hour during a 24 hour day. This is not uniformly distributed, however, For example, the solar intensity in Madison, Wisconsin, on a sunny day in June may be as high as 2500 BTU/ft^2/day to as low as 600 for a sunny day in December, a four to one ratio. Of course, in cloudy weather, this may be reduced to a small fraction of these values. Here in North Carolina the annual variation is less than in Madison and also the total radiation is higher.

Assuming that we have 1500 BTU/ft^2/day of solar radiation, we can estimate how much drying can be expected if we know the efficiency of using this energy. This depends on the size and efficiency of the collector and on the efficiency of using the energy which is collected.

Most solar-heated dry kilns used for lumber drying consist of a wood frame covered with one or two layers of transparent material such as glass or plastic, and operate essentially like a greenhouse, trapping the solar energy after it is converted to heat energy by black-painted surfaces within the kiln (Figure 3). The heated air is circulated through the lumber by means of electric fans as in a conventional kiln. According to Wengert (1971) who made a study of the energy losses in such a solar dryer at Colorado State University, only 16 percent of the total solar energy impinging on the kiln was actually converted into useful drying energy. The energy losses of 84 percent were accounted for by convection (20%), reradiated solar energy (17%), ventilation (14%), longwave thermal radiation (13%), and conduction through the floor of the kiln (11%). Wengert made certain suggestions for improving the overall performance of the kilns.

From the above analysis of Wengert, it is clear that the total available energy in such a greenhouse type of kiln is only a small fraction of the

incident solar energy. Assuming that the kiln can be improved to 20 percent efficiency, it is possible to calculate how much collector area is required to dry a given quantity of lumber. It should require about 2,000,000 BTU to dry one thousand board feet of green lumber of 70 percent moisture content to 10 percent for oak of 0.6 specific gravity. Assuming the total effective collector area of the kiln is 200 square feet with a total efficiency for drying of 20 percent of incoming radiation, it would require 20 sunny days in June with a radiation intensity of 2500 BTU/ft^2/day and 83 sunny days in December with radiation intensity of 600 BTU/ft^2/day. Incidentally, this efficiency of 20 percent is approximately half of the estimated efficiency of 40 percent for ordinary dry kilns. It should also be remembered that the circulating fans also consume energy. This may be as high as 10 percent of the total energy used in some cases.

Solar energy can be used as an additional booster for conventional drying, either in predrying or as a supplement to the standard kiln-drying process. Cuppett (personal correspondence), for example, has been experimenting for several years at the Forest Products Marketing Laboratory in Princeton, West Virginia, with a solar-supplemented predrier. A sophisticated solar lumber drier has been built and tested in Australia (Read, et al, 1974). In this case, a separate collector for heating air has been used, together with a rockpile heat storage system and a separate kiln, has been used (Figure 3). Solar kilns have been used throughout the world over the past 20 years, but mostly on a laboratory or pilot plant scale. The Energy Research and Development Administration has received proposals for using solar energy to supplement the drying process for many materials, including lumber. It is expected to fund research in this important area of solar energy use when the proposals are evaluated this spring.

The drying of lumber has one advantage over other uses of solar energy in that dry lumber is an efficient energy storage system. For example, when solar energy is used to dry the surface of lumber during daylight hours, the surfaces of the lumber become dry compared with the interior. During the night, the moisture tends to equalize throughout the lumber because of the drying potential of the dry surface layers. Thus, drying from the interior occurs during the night hours and drying from the exterior surfaces during the sunlight hours. However, this phenomenon may cause severe surface drying stresses of such an extent that surface checking may occur. This can be controlled in the same way as is done in a conventional kiln, by proper control of the venting system. Furthermore, it is possible to sense periods of excessive surface checking by use of acoustic emission detectors as is described in the next section.

C. Acoustic-Controlled Drying

Prior to World War I the drying of all lumber was accomplished primarily by a "seasoning" process in which the green lumber was exposed to the atmosphere under conditions which permitted it to dry "naturally". This air-drying process is still followed today for hardwoods to a considerable extent as a preliminary step to the accelerated final drying in an artificially heated atmosphere such as is maintained in a dry kiln. Modern kiln-drying is a more or less sophisticated process in which lumber is dried as rapidly as possible by suitable combinations of heat and humidity.

For softwood lumber intended for construction uses the drying process consists essentially of evaporating water from the wood as rapidly as possible by maintaining high temperatures and air velocities in the kiln until the wood is sufficiently dry. On the other hand, hardwood lumber is often intended for end uses in which appearance and dimensional stability, as well as freedom from drying defects, are important. In this case the maximum drying rate is governed by other factors than the rate at which heat can be supplied to the lumber, or the evaporated moisture can be removed.

In order to evaporate water from wood, it is necessary to transfer heat to the surface of the wood as well as to the interior. It is also necessary to transfer the moisture from the interior of the wood to the surface and from the surface to the drying air. The drying process can be viewed as being limited either by the rate at which moisture can be moved to the surface from the interior of the wood or else by the rate at which it can be removed from the surface. It is sometimes convenient to discuss the limitation imposed by these two factors in terms of their relative resistances to the drying process. In this case the resistance to internal evaporation and/or moisture movement may be lumped into one term designated as the internal resistance to drying. Similarly the resistance to external evaporation, removal, and heat transfer may be designated as the external resistance.

The drying rate for hardwoods is limited by the magnitude of the internal stresses which develop during drying. These stresses arise from at least two factors. One of these is the development of moisture gradients which result from the normal drying process in which the moisture is first evaporated from the wood surface. This lowers both the water vapor pressure, p, and also the hydrostatic pressure, P, of the water near the wood surface compared with that in the interior. The lowering of the vapor pressure, p, of the surface moisture compared with that of the wood interior is small, being much less than one atmosphere (15 psi) in the ordinary dry-kiln temperature range. However, the hydrostatic pressure, P, of the water in the cell wall of the surface layers is generally lower by many atmospheres than that of the water in the wood interior. In fact, it is actually in tension relative to the water in the interior, and therefore literally "pulls" the water from the wet interior towards the drier surface. Table 1 gives the order of magnitude of this tension pull of the water in a partially dry wood surface of various moisture contents on the water in the interior of the wood (assumed to be at or above fiber saturation) for a temperature of 100°F.

It is clear from Table 1 that the stresses associated with the water tension can be tremendous. However, these stresses are generally limited to the cell wall itself which is strong enough to withstand them. However, if they are transmitted to cells within the wood which are filled with water they can pull on this "free" water with sufficient force to collapse the cells under certain conditions. These conditions are that the cells are completely water-filled and that there are no air-water interfaces in the cell or in nearby cells which can relieve the tension by expansion into the cells.

Another important factor which determines if the stresses are sufficient to cause collapse is the distance between the surface and the nearest cells

which are subjected to the conditions necessary to cause collapse. If this distance is short, that is, if the moisture gradient is steep, collapse is more likely to occur than if the distance is large. This is because the tension difference between any two adjoining cells is less if the gradient is less steep. The tendency of individual cells to collapse increases with temperature since higher temperatures weaken the wood cell walls and generally result in steeper moisture gradients.

In addition to causing collapse in individual cells or interconnected groups of cells, the tremendous tension forces in the cell walls associated with lower humidities around them also causes the walls to contract or shrink. Furthermore, the shrinkage is not the same in all directions within an individual cell, and different cells shrink differently, causing shrinkage stresses between individual cells and between groups of cells of different structure. These kinds of stresses are particularly acute between the longitudinal tissues which comprise the bulk of wood and the radial tissues which make up the rays. Most of the defects which occur during hardwood drying take the form of checks or cracks at the interface between the rays and longitudinal tissues. It is the goal of most hardwood drying to minimize the development of these checks and still dry the lumber as expeditiously as possible.

Hardwood lumber drying schedules have been developed for different wood species based on the experience of many individuals in successfully drying these woods, and schedules are given in terms of average moisture contents of sample boards. These are only empirically related to the rates at which defects occur during the drying process. It would be desirable to have the drying controlled directly by the rate at which drying defects occur if this could be monitored during the actual drying of a load of lumber. A proposed method for doing this will be described here.

The formation of a check or crack in wood, whatever be the cause, always results in a sudden release of energy. A similar phenomenon results in the "snap, crackle, and pop" given off by a certain well-advertised breakfast cereal when it is wetted by milk. Similar sounds can be heard when dry wood is wetted and also when wet wood is dried. The problem is that the sounds released are usually of such a low level that they cannot easily be detected. What is needed is an acoustic amplifier, similar in general principle to a physician's stethoscope which can be used to monitor the "health" of the wood as it dries. Based on the acoustic analysis the drying process can then be controlled in order to minimize the frequency of acoustic emissions (an indication of the rate of check formation) consistent with maximizing the rate of drying.

Some exploratory work was carried out 10 or 12 years ago to determine if a relationship could be established between the number of acoustic emissions of beech and of oak samples dried in a low temperature oven, and the number of surface checks which developed. The results were promising but the instruments were crude and the work was discontinued at the time. However, there has been a tremendous development in the past few years of the techniques and instruments used for relating acoustic emmissions of materials being tested for mechanical properties and the development of microfailures in the materials. Actually, similar effects were found over 12 years ago by Porter (1964) in working with wood subjected to mechanical

stress in a testing machine.

What is needed now is additional research to determine the practicability of using modern acoustical emission techniques and instrumentation for monitoring the development of surface and internal failures during hardwood lumber drying. There are a number of practical and theoretical problems associated with the technique which may be too difficult to overcome at the present level of technology. However, there certainly is enough intrinsic merit to the concept to make it worthy of further investigation. Figure 4 shows a schematic diagram of the sensing and control system which might be used.

Table 1. Interrelationships of Percent Relative Humidity (R.H.), Percent Moisture Content (M.C.), Hydrostatic Tension (T), and Water Vapor Pressure (p) at 100°F

R.H. (%)	M.C. (%)	Hydrostatic (atmos.)	Tension (T) (psi)	Vapor Press. (p) (psi)
100	FSP	0	0	0.908
90	20	142	2,100	0.817
80	15	400	5,900	0.726
70	13	477	7,000	0.636
60	10	680	10,000	0.545
50	9	917	13,500	0.454

References

1. Daniels, J. Farrington. 1964. Direct use of the sun's energy. Yale Univ. Press. New Haven. 374 p.

2. Peck, E. C. 1962. Drying 4/4 red oak by solar heat. Forest Prod. J. 12(3):103-107.

3. Porter, A. W. P. 1964. On the mechanics of fracture in wood. Ph.D. Thesis. SUNY Coll. Forestry. Syracuse. 215 p.

4. Read, W. R., Choda, A., and Cooper, P. I. 1974. A solar timber kiln. Solar Energy 15:309-316.

5. Tiemann, H. D. 1959. Highlights leading up to modern kiln drying. Forest Prod. J. 9(1):11A-14A.

6. Wengert, E. 1971. Improvements in solar kiln design. U.S. Forest Serv. Res. Note FPL-0212.

7. Youngs, R. L. 1959. Recommendations of the Madison conference on fundamental research in wood drying. Forest Prod. J. 9(3):121-124.

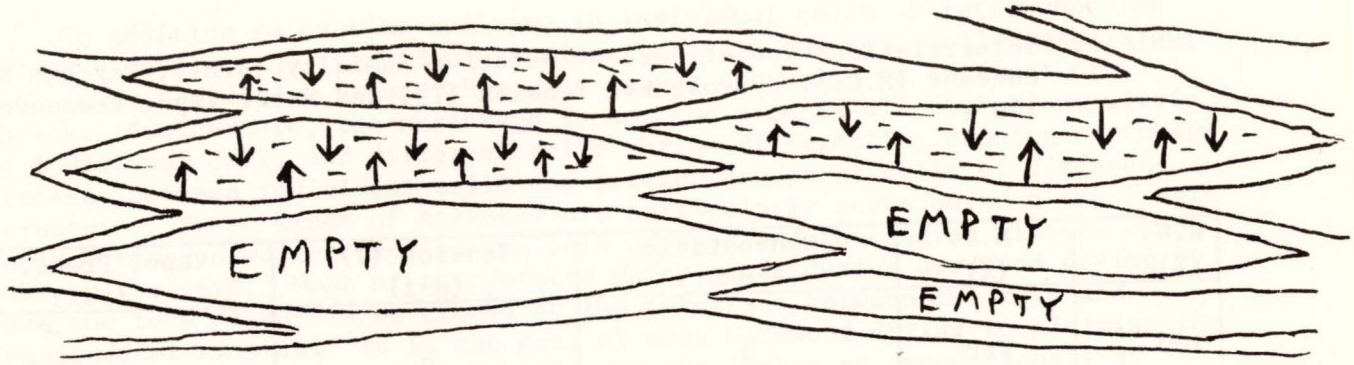


FIG. 1. COLLAPSE OF CELLS BECAUSE OF WATER TENSION

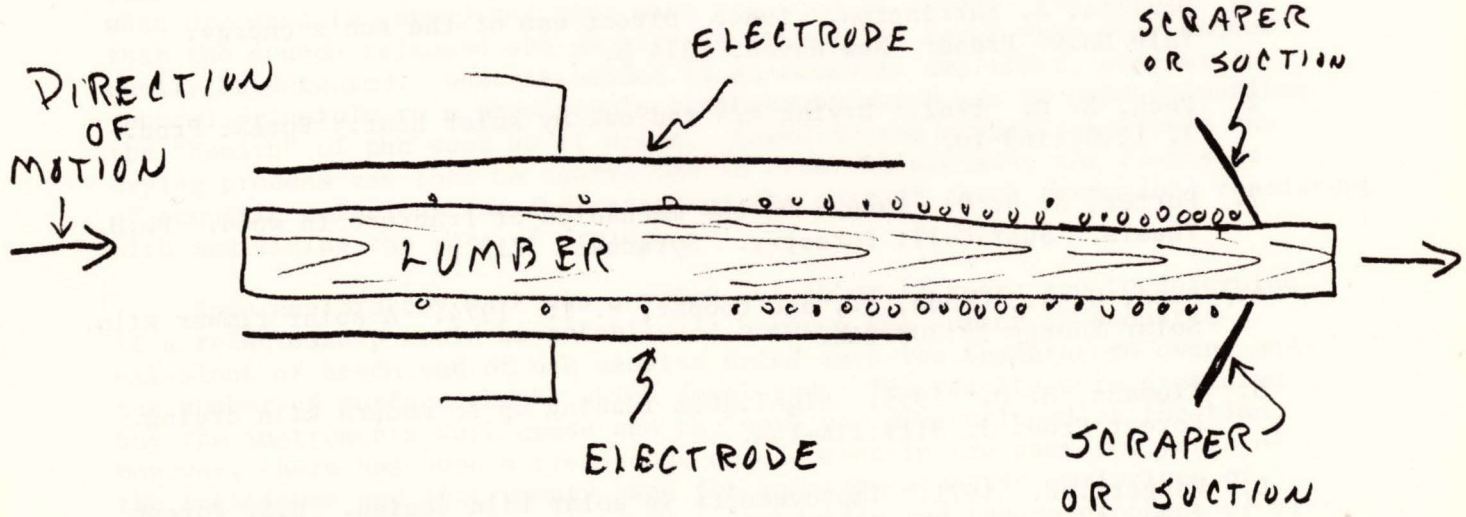


FIG. 2.
"RF" DRYING SCHEMATIC

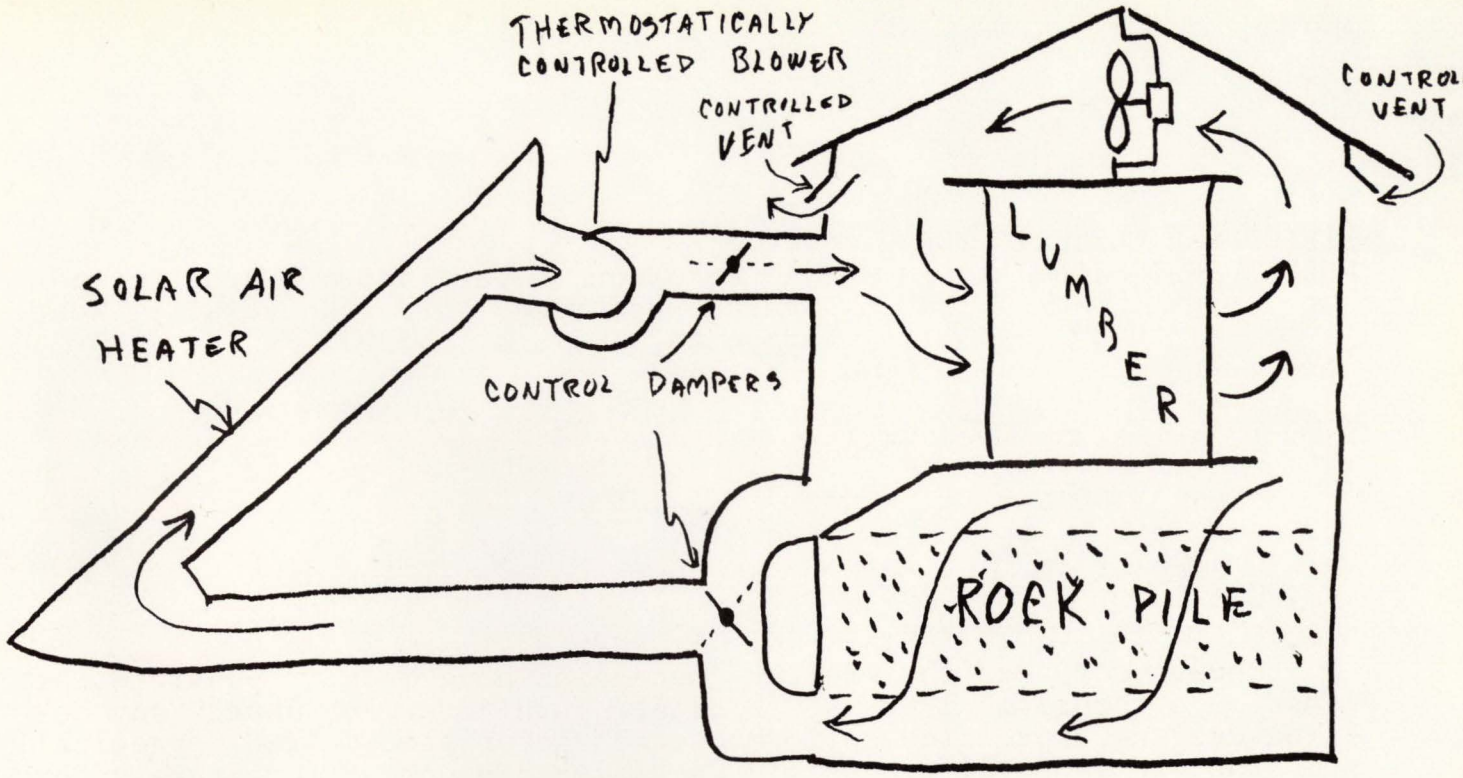


FIG. 3. AUSTALIAN SOLAR DRY KILN

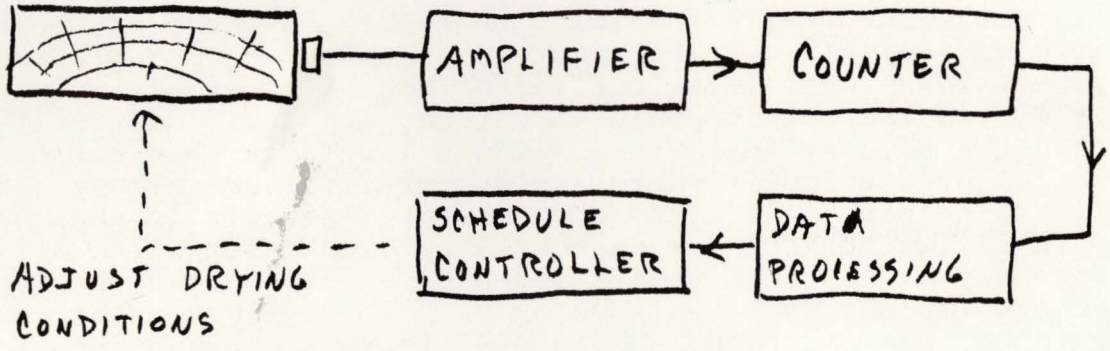


FIG. 4. DRY KILN CONTROL BY ACOUSTIC EMISSIONS

STRUCTURAL CRITERIA FOR FURNITURE DESIGN

- C.A. Eckelman, Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana 47907.

STATEMENT OF PROBLEM

Recent advances in furniture mechanics have made it possible, at least on a theoretical basis, to create furniture with nearly any desired designer-specified performance characteristics. Yet, practically speaking, it is still impossible to design a piece of furniture according to any rational procedure which can be guaranteed to hold up in service. The unresolved issues which lead to this apparent contradiction can be separated into two broad categories - those that deal with conditions of use, namely, loads and time; and those that deal with details of construction, namely strength.

LOADS

Before we can determine how strong to build a piece of furniture, we must first know the nature of the loads it will carry in service. Service conditions for furniture have not been adequately defined so that neither service loads nor service life have ever been specified in usable quantitative values. And what is even more important, "normal" conditions of service have not been defined. Thus even though we do know the magnitude of a small number of service loads, we still do not know whether to classify them as "normal" or "abusive".

Presumably, furniture could be constructed which could resist the largest load that might ever be imposed on it in service. Such a course of action is not economically feasible, however, and would not be in the best interests of either manufacturers or consumers. Furthermore it would result in an extremely inefficient use of materials. Few furniture failures are catastrophic in nature, and it is difficult to justify using the same criteria in designing furniture that are used in designing major structures where a structural failure almost certainly leads to personal injury and loss of life. It is necessary, therefore, to differentiate between normal service loads which arise when the furniture is performing its intended function, and abusive loads which are imposed when it is being used in some way other than that for which it was intended. Obviously, there are exceptions to this statement, but in general, differences between the two design philosophies must necessarily be recognized.

In order to determine how long a piece of furniture will hold up in service, we must know not only the magnitude of the various normal and abusive loads it must carry but also their frequency of occurrence. Presumably a piece of furniture fails in service for one of two reasons --

either it fails from fatigue or else it fails because it was overloaded. The problem that exists here is accordingly a twofold one. First, what is the fatigue resistance of the furniture at various load levels, and secondly, what is the frequency of occurrence of these load levels during a finite period of time which is designated as the service life of the furniture. Actually, the problem is more probabilistic than deterministic. This becomes evident when we consider a specific piece of furniture such as a sofa which may be subjected to a rather large number of possible load configurations. Such a sofa may very well carry from 1 to 5 people, each of whom may range in weight from perhaps 6 to over 300 pounds. In evaluating such loads, we must necessarily consider the average load carried, the distribution and range of the loads, their frequency of occurrence during a specific period of time, and the distribution of extreme loads as they occur on a day to day basis. Regardless of its nature, however, the problem that exists is that until load models are developed which faithfully reflect conditions of service, furniture cannot be designed according to any systematic procedure which will insure that it will survive in service for any prescribed length of time.

STRENGTH OF MATERIAL

In order to predict the strength and reliability of a piece of furniture, we must also know the characteristics of the material used in its construction. In particular we need to know its average ultimate strength, its variability, and its lower tolerance limits so that basic design stresses can be determined. Yet, very little of this type of information is available which can be used in the design of furniture. Hardwoods, for example, have always been the material of choice for furniture, but we still know very little about their strength properties as they are used in this type of construction. Basic ultimate strength values for most of the commercially important native hardwood species have been published in the Wood Handbook (Anon., 1955), but these values cannot be applied to the strength design of furniture without suitable modification for two reasons: first, they are based on tests of perfectly clear, straight-grained specimens, and secondly, the values presented are average values. Naturally, we cannot expect wood used in furniture production to be of the same quality as wood which has been carefully selected for laboratory specimens. A certain amount of cross grain as well as blue stain and even an occasional knot must normally be expected. As a result, the actual strength of furniture parts will often be much less than expected if calculations are based on clear wood strength values. Furthermore, since the values given in the Wood Handbook are for average ultimate strength, it must be remembered that about half the specimens could be expected to fail at stress levels below those given. What is needed for design purposes, however, are the least strength values that can be expected rather than the average values. Furthermore, we need to know the fatigue life of the material so that the service life of the parts can be predicted. This is particularly true in the case of some plastic parts which have high static strengths but readily fatigue at low stress levels.

We also need to know how well the quality of the materials can be monitored and controlled during the course of manufacture. To what extent, for example, can defects such as cross grain, brash grain, knots, and so on be located and eliminated in wood used for furniture parts. To what extent can the species being used be identified and controlled. Practically speaking, it is often impossible to separate many of the wood species. It is often quite difficult, for example to separate tupelo from the sapwood of sweetgum, and they are often used interchangeably even though there is a considerable difference in their bending strengths. In the case of plastics, the problem that exists is that the strength of the end product depends upon the quality and proportions of the initial components used as well as on the molding process itself. The strength values of actual molded parts are, accordingly, often only a fraction of what would be expected from a consideration of published strength values.

STRENGTH OF JOINTS

Because of esthetic considerations, the strength and service life of a piece of furniture usually depend more on the strength properties of the joints used in its construction than on any other single factor. This follows because the joints, particularly when they are exposed, usually may be no larger than the members they join together, and for reasons of appearance they cannot be reinforced with gussets. With current construction techniques, such joints can develop a maximum of only about 25 percent (Eckelman, 1968) of the bending strength of the members, and, in most cases, therefore, the joints are much weaker than the members they join together. Because of these limitations, the maximum strength which can be developed in many critical joints is often less or only slightly greater than the actual service strength required of the joint. There is no simple solution to this problem, and in many cases, it can only be solved by using members of larger cross section or by redesigning the structure so that other members carry a greater share of the load. Regardless of the solution, however, it is evident that if we are to design a reliable piece of furniture with a specified service life, we must be able to predict the strength of the joints quite accurately, or else excessively inefficient member sizes must necessarily be used to compensate for our ignorance.

Once the forces which act on the joints have been determined, the joints can be designed so that they can resist these forces with any desired factor of safety. In practice, however, there are no formulas available which can be used to design furniture joints. Until recently, essentially all of the joint research carried out has been qualitative rather than quantitative in nature. For the most part, it has been concerned with how to make stronger joints rather than how to design joints of specified strength. The principal reason for this course of action is that such research has not been carried out within the framework of an engineering oriented program, strength requirements were accordingly never defined, and under these conditions research leading to improvement in joint strength even though carried on without regard to design criteria has been a worthwhile objective in itself. Recent research, however, has lead to the development of expressions which can be used to provide reasonable estimates of the average ultimate strength of several of the most commonly used furniture joints and fasteners (Eckelman, 1970 etc.). Although these expressions are of considerable help, what are actually needed for design purposes are

the least strength values that can be expected from such joints a specified percentage of the time; i.e., their lower tolerance limits. Furthermore, these expressions are based on a limited number of tests of laboratory specimens. Little is known about the strength of joints manufactured under production line conditions, and until predictive expressions can be developed for such joints, we cannot hope to predict the service life of furniture.

We must also know the fatigue characteristics of furniture joints. As was previously stated, most furniture joints are highly stressed and are thereby susceptible to early fatigue failure. Tests have shown (Eckelman, 1970), for example, that dowel joints, which are one of the most widely used joints, readily fatigue at high stress levels. Since there is no practical way, in most cases, of markedly increasing the strength of such joints and thereby raising their fatigue strength above the required strength, their fatigue characteristics must accordingly be well-defined before the service life of the furniture of which they are a part can be predicted.

The inherent reliability and predictibility of individual joint systems must also be considered. Experience has shown that certain joint and joint construction practices are naturally more dependable than others. The withdrawal strength of a screw, for example, is a relatively predictable quantity, whereas the shear strength of a glue block is generally rather unpredictable. In some joints, multiple fasteners are used so that the joint has a degree of redundancy, and failure of a single fastener will not lead to its complete collapse. Other joints are constructed so that primary loads are transferred directly from member to member rather than being transferred through fasteners.

In considering the structural reliability of furniture we must also take into account the ease with which joints can be inspected and their quality controlled on a production-line basis. Generally, speaking, the quality of mechanical joints can be more easily determined than adhesive based joints. It is almost impossible, for example, to tell whether or not any glue has been used in a dowel joint, whereas mechanical joints can often be designed so that a simple visual inspection will disclose whether or not the joint has been properly constructed. This consideration may weigh heavily in favor of mechanical joints for use in guaranteed furniture.

ANALYTICAL TOOLS

Before we can determine how large a member should be or how strong a joint should be, we must first be able to determine the magnitude of the internal forces with act upon them. Unfortunately, most forms of furniture are such complex structures that it is impractical to try to analyze them with manual computational methods. Furniture members are often curved and of non-uniform cross section. Joints are semi-rigid rather than rigid and behave non-linearly. They are also of such size relative to the frame members that their dimensions cannot be ignored. Finally, the geometry of the total structure is frequently irregular and so highly indeterminate that planar representations of it cannot be used. Simplifications which are commonly used in the analysis of textbook problems, therefore, usually cannot be used in the analysis of real furniture frames.

An additional problem arises in that there are few structural analysts in the furniture industry. This presents a particularly perplexing situation. If we are to have furniture with guaranteed reliability, we must be able to determine the forces acting on the members and joints so that they can be designed to hold up in service. Yet to do this, an industry which has had little experience in structural analysis must be able to analyze structural forms which are of above average complexity. Furthermore, it must do so economically - the accurate analysis of most furniture frames is not feasible if the large volume of necessary arithmetic cannot be accomplished at low cost. Finally, it must be able to carry out these analyses quickly since the elapsed time from conception to production is relatively short for most furniture. The answer to these problems appears to lie in the development of fast, efficient, computer-based analytical tools which can be used by industrial technicians as well as specialists in structural mechanics. Progress has already been made in this direction. Two computer programs have been developed specifically for the analysis of furniture frames. The first program treats a specific furniture form; namely, chair side frames, whereas the second is much broader in concept and can be used to analyze frames of almost any type and configuration. In general, these programs have demonstrated the feasibility of this approach to the analytical problem, but a great deal of developmental work remains to be done to determine the most useful forms of analytic systems for the furniture industry, and furthermore, several difficult analytic problems remain to be solved.

PLAN OF RESEARCH

LOADS

As was previously stated, before we can determine how strong to build a piece of furniture so that it will hold up in service a specified length of time, we must first have a detailed knowledge of the loads it will be called upon to carry. At the present time the most critical need is for load information concerning furniture that is used for sitting purposes; principally chairs of all types, sofas, and sofa-beds. Consumer pressures for guarantees on this type of furniture already exist and are likely to increase in the future so that it is essential that a rational basis for their design be promptly established. Furthermore, human safety must also be considered since failure can lead to personal injury and subsequent costly liability suits as well as simple customer dissatisfaction. A balance betwen material and human safety considerations must accordingly be found - it is important that adequate factors of safety be provided, yet it is equally important that these factors of safety be no larger than necessary because of material cost considerations which would penalize both the manufacturer and the consumer. Simply stated, it is no longer feasible to use an excess of material to compensate for a lack of knowledge of exact structural requirements.

Of all the loads applied to furniture, those applied to chairs and sofas taken as a group are perhaps the most complex and difficult to measure. Such loads usually have no well-defined point of application, are quite variable in nature, contain both static and dynamic components, and are generally applied with irregular frequency over a finite period of time. In addition, apparently very little related research has been carried out which can be used in synthesizing them, although the body characteristics of the population taken as a whole

are relatively well known. As a result, it will be necessary to make many physical measurements of the forces imposed on sitting-type furniture by human subjects. Optimistically, correlations can be found between body weight and applied forces so that a number of deductions can be made based on known distributions of population characteristics and the number of measurements required thereby greatly reduced.

In carrying out this research there are perhaps four primary areas of interest to consider. First, what are the characteristics of the various service loads and how can they be specified. Are they static or dynamic in nature, where are they applied, and how can they be represented. Can we use a single concentrated static force applied at a specific point to represent a back load, for example, or must we use some type of distributed loading? Secondly, what is the magnitude of these forces and what is the proportion of the total population represented by any specified set of values? What is the mean value of a specific load, its standard deviation, and its upper tolerance limit? In short, what is its frequency distribution? This is an important consideration because it would be extremely inefficient to design all furniture so that it could carry the largest loads imposed by all segments of the population. Furthermore, what constitutes a reasonable proportion of the population will eventually likely need to be defined for design purposes by general agreement of manufacturing, consumer, and federal regulatory groups so that a manufacturer can design his furniture to meet generally accepted standards. Thirdly, what is the frequency of occurrence of various types of loads during a particular length of time? How often is a kitchen chair used during the course of a year, for example, or a sofa? Similarly, how often is institutional furniture used? Another question which remains to be answered is what constitutes normal frequency of use for both types of service? Here again, frequency distributions are needed to adequately describe the problem. In particular, if cumulative frequency curves are drawn, it seems likely that frequency of use can be broken down into regions that are closely associated with intuitive concepts of degree of usage. The following intuitive separation or breakdown might be used, for example, progressing from lowest to highest frequency of use: a) light duty household, b) medium duty household, c) heavy duty household and light duty institutional, d) medium duty institutional, e) heavy duty institutional. Fourth, what is the distribution of maximum loads that act on the structure with respect to time. Specifically, based on the previous studies we would like to be able to predict the probability that any specified load value will be exceeded during a fixed period of time. This type of information is of particular interest in the case of furniture such as sofas where the loadings can be quite variable, although it is just as important in the design of single seating units. Furthermore, this information is fundamental to the eventual application of structural reliability theory to practical design problems.

Loadings for other types of furniture can be determined using techniques somewhat similar to those described for furniture designed for sitting, but in most cases the problems involved are not expected to be as difficult to treat. In the case of furniture designed primarily for storage purposes, for example, maximum loads can be

determined from a consideration of available volume and density of contents.

MATERIALS

Essentially, there are only three types of materials used in furniture construction; namely, wood and wood base materials, metals, and plastics, yet we know very little about there strength and performance characteristics as they are used in furniture. In the case of wood, allowable design stresses have been developed for the commercially important hardwood and softwood species as they are used in residential and other types of conventional building structures. For the most part, however, these stresses are far too conservative for furniture construction since they are based on conditions and defects which for the most part do not apply to furniture. Structural lumber, for example, is graded on the basis of the anticipated strength of a piece over its entire length. What is important in furniture construction, however,is what is the strength of the dimensioned part itself rather than the strength of the material from which it was cut. Hardwood grades on the other hand are graded in terms of the number of clear cuttings that can be obtained, without regard for strength. Consequently, these grades are of no value in determining allowable design stresses.

The most critical need is for information relating to bending strength which can subsequently be used in developing allowable design stresses in bending for wood. Furniture parts are ordinarily most highly stressed in this manner, and the required size of a part is generally governed by bending strength reqiurements. There is also a need for data concerning the horizontal shear strength of wood. Ordinarily, this characteristic is of little concern, but in some deep front rails, horizontal shear failures can occur. This is particularly true if the rail has been grooved or otherwise machined to receive the upholstery material. Calculations indicate that the shear stresses in such rails can easily reach several hundred psi so that they cannot be ignored in the design process. The torsional shear strength of the wood also requires investigation so that allowable design stresses can be established for this property also. Furniture is one of the few structures in which wood is regularly loaded in torsion. The sinusoidal seat springs used in many sofas and chairs, for example, exert sizeable torsional forces on the front and back rails. Furthermore, the stumps in this type of furniture often impose large torsional forces on the back uprights, particularly if the sofa or chair is stacked on end during shipping.

The other mechanical properties of wood, including compression parallel and perpendicular to the grain, and shear parallel and perpendicular to the grain, are less important for furniture design processes, and it is anticipated that reasonable allowable design stress values can be developed for them from existing data.

In developing allowable design stresses for woods used in furniture construction, it will be necessary to carry out strength tests on production-line parts rather than on laboratory samples. Furthermore, it is important that the samples be tested the way they are used - if they are loaded on edge they should be tested on edge and if used flat, tested flat. These samples should be randomly selected from the

production lines of manufacturers located in representative regions of the country. The success of this program will depend to a certain extent, accordingly, on the willingness of various manufacturers to participate in the program. It is not anticipated that any great difficulty will be encountered in obtaining such samples since the aid of the major furniture associations can almost certainly be enlisted.

JOINTS

Before we can predict the strength, service, life and reliability of a piece of furniture, we first must be able to predict these same characteristics for the joints used in its construction. In particular, we must be able to predict the average ultimate strength of each joint, the least strength that can be expected from each joint a predictable percentage of the time (i.e., its tolerance limit), the fatigue strength of each joint, and finally, what percentages of these values are obtained under production-line conditions. Studies are accordingly needed to first evaluate the average ultimate strengths that can be obtained from the various joints used in furniture construction. From these studies, empirically based formulas can be developed to predict the average ultimate strength of each type of joint. These studies will also provide information concerning the natural variability in strength that must be expected even when the joints are constructed under ideal laboratory conditions. To some extent, therefore, the results of these tests provide crude estimates of the reliability of the various types of joints used in furntiure construction. More importantly, however, they make it possible to determine the least strength that can be expected a specified percentage of the time, and this is the type of information that is presently required for design purposes. Provided the necessary resources are available, these studies should be integrated with a theoretical approach to joint design so that reliance on laboratory tests can be decreased. Also, provision should be made so that new joint designs can be developed and evaluated whenever the opportunity presents itself.

The fatigue characteristics of each type of joint must also be evaluated. The geometry of furniture joints - the usual presence of stress raisers - suggests that they should be particularly prone to fatigue damage. Research carried out on one of the most widely used joints, the dowel joint, tend to bear out this assumption (Eckelman, 1970). Presumably, tests should indicate that some joints are more prone to fatigue than are others. Methods of improving the fatigue life of joints which are currently used should also be investigated for it is entirely possible that minor changes in the construction of these joints can significantly improve their fatigue strength. By using joints which have the highest fatigue resistance whenever possible and using general techniques which increase fatigue life, the service life of furniture could perhaps be meaningfully increased without essentially changing the furniture or adding to its cost.

Fatigue limit relationships also need to be established so that the service life of each type of joint can be predicted. It seems likely here that the fatigue life of the joints can be closely associated with the categories of usage that have previously been discussed under the heading of loads. On an intuitive basis, for example, it seems reasonable that a dining chair in a restaurant

receives harder usage than one in a home. This does not necessarily mean that it must carry heavier loads, however. Rather it indicates that it is used more frequently and is more likely to fail from fatigue. Thus a chair designed for institutional use should be more resistant to fatigue than one used in the home if it is to hold up in service for the same length of time.

ANALYTICAL TOOLS

Development of analytical tools should follow a dual course of development. Additional work is needed in the general area of furniture mechanics in order to develop and verify methods of analysis for pure panel type and also mixed frame and panel construction. These systems are used primarily in case and carcass construction and their analysis can be quite complex. Studies of reliability and the strength design of furniture are necessarily based on furniture mechanics, and it is essential that developments in this area precede those in other areas.

As was just stated, advances in reliability and strength design of furniture must necessarily be based on a thorough comprehensice knowledge of the underlying principles of furniture mechanics. As this field develops and we learn more about the behavior and characteristics of individual parts in furniture, however, attempts must be made to develop simplified methods of analysis which can be used by large segments of the furniture industry rather than by a few trained specialists. Considerable progress, for example, has been made by the author in developing a simplified computer program which analyzes the individual members in a frame one at a time rather than analyzing the structure as a whole. This system was made possible by first analyzing representative samples of furniture to determine the end restraints ordinarily imposed on each member and then incorporating these restraints into the program itself. Generally, there is some loss of accuracy in using this method, but the advantages of the method usually outweigh the disadvantages, and the program does demonstrate the feasibility of the concept. Such programs have added significance in that once developed they can be used to develop standard member sizes for the various structural parts used in furniture. This follows because required member sizes are calculated independently of the total geometry of the piece of furniture as a whole. In short, therefore, such programs should ultimately provide the tools needed to evolve minimum standard sizes for the structural members used in furniture.

SUMMARY

The subject of strength design of furniture and structural reliability is an exceedingly complex one, and the principles and techniques required for evaluating the reliability of even the most simple conventional structures have only recently been developed. As it applies to the furniture industry the problems associated with reliability are particularly preplexing. The strength design of furniture is still based on tradition and experience, and it has not as yet entered an engineering design stage of development. Yet, if the furniture industry is to produce furniture with a guaranteed service life on an efficient basis, it must necessarily utilize analytical techniques which are associated with an even higher level

of technical development since reliability can only be rationally qualified by statistical methods. The loads and strengths associated with furniture, for example, are variable quantities and realistically can be described only as statistical variables. Reliability analyses must accordingly consider loads and strength as frequency distributions. This presents a formidable task when it is realized that not a single clearly defined point has as yet been established for either type of distribution. Regardless of the state of existing knowledge, however, we must necessarily recognize at this point that design is essentially a process of making predictions about uncertain phenomena, and it is, therefore, an inherently statistical process. Given the state of knowledge that currently exists, it seems clear that initial reliability studies must necessarily be oriented towards obtaining basic engineering design data. On the other hand it is equally clear that such research must be carried out within a statistical framework of reference so that the information developed can ultimately be used in making probabilistic determinations of the safety and reliability of furniture. Given this research philosophy and the constraints imposed by the state of technology that now exists, the following research needs can be cited which are essential to the ordered development of a program of guaranteed reliability for furniture.

1. The type, magnitude, and frequency of occurrence of the loads which act on furniture must be determined and load models developed for design purposes, which faithfully reflect the action of these service loads.
2. The strength properties of the materials used in furniture must be evaluated as they are used in actual construction practice and allowable design stresses developed for them which take into account the natural variability of the material and the numerous process variables.
3. The strength characteristics of joints used in furniture construction need to be defined both under ideal and production line conditions and formulas developed to predict their allowable design strength.
4. Simple, efficient techniques need to be developed and existing techniques improved for determining the internal forces acting on the various structural parts and joints of furniture.
5. The relative inherent reliability of the various structural systems, now in use need to be evaluated, methods of improving reliability investigated, and guidelines of preferred practice prepared.
6. A general purpose furniture service simulator needs to be developed and constructed which is capable of faithfully duplicating the effects of year's of service on a piece of furniture in a short length of time and which can be used to lay the groundwork for the development of simplified performance tests which can be used by manufacturers to qualify their furniture for various use categories corresponding to stated warranties.

Selected References

Eckelman, C.A., 1966. A Look at the Strength Design of Furniture. Journal Paper 2645. Forest Products Journal: Vol. 16, No. 3, p. 21.

Eckelman, C.A., 1967. Furniture Mechanics: Chair Frame Analysis and Deisgn. Journal Paper 2875. Forest Products Journal: Vol. 17, No. 9, p. 100.

Eckelman, C.A., 1967. Furniture Mechanics: Framed Cabinet Furniture P.U. Agr. Exp. Sta. Bul. No. 826.

Eckelman, C.A., 1967. Furniture Mechanics: The Analysis of Paneled Plate and Carcass Furniture.P.U. Research Progress Report No. 274.

Eckelman, C.A. and F.E. Goodrick, 1967. Optimum Wood Moisture Content Levels for the Manufacture of Furniture in Indiana.P.U. Research Progress Report No. 311.

Eckelman, C.A. and F.E. Goodrick, 1968. Computer Analysis of Member Stresses in Chair Side Frames.P.U. Research Progress Report No. 325.

Eckelman, C.A., 1968. Furniture Frame Analysis and Design.Unpublished PhD Thesis, Purdue University (May be obtained from University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan. 48106).

Eckelman, C.A. and S.K. Suddarth, 1969. Analysis and Design of Furniture Frames. Journal Paper 3575. Wood and Science and Technology, Vol. 3, No. 3.

Eckelman, C.A., 1969. Engineering Concepts of Single-Pin Dowel Joint Design. Journal Paper 3671. Forest Products Journal, Vol. 19, No. 12.

Eckelman, C.A., 1970. The Fatigue Strength of Two-Pin Moment Resisting Dowel Joints. Journal Paper 3965. Forest Products Journal, Vol. 20, No. 5.

Eckelman, C.A., 1970. The Stiffness Matrix Method of Furniture Frame Analysis. Journal Paper 3654. Wood Science, Vol. 2, No. 4.

Eckelman, C.A., 1970. CDFF -- Computer Design of Furniture Frames: Part I - User's Manual.P.U. Agr. Sta. Bul. 857.

Eckelman, C.A., 1970. CDFF -- Computer Design of Furniture Frames: Part II - Engineering Concepts.P.U. Agr. Exp. Sta. Bul. 863.

Eckelman, C.A., 1971. CDFF -- Computer Design of Furniture Frames: Part III - Program Documentation.P.U. Agr. Exp. Sta. Bul. 876.

Eckelman, C.A., 1970. Comparison of The Strength of Wood and Plastic Beams.P.U. Agr. Exp. Sta. Prog. Rept. 374.

Eckelman, C.A., 1970. How to Design Dowel Joints.P.U. Agr. Exp. Sta. Prog. Rept. 373.

Eckelman, C.A., 1970. Chair Stretchers and Spindles Prove Tough After Purdue Testing. Furniture Design Magazine, Sept. 1970.

Eckelman, C.A., 1970. How to Design Plastic Furniture. Society of Plastics Engineers Journal, Nov. 1970.

Eckelman, C.A., 1971. Bending Strength and Moment-Rotation Characteristics of Two-Pin Moment-Resisting Dowel Joints. Journal Paper 4217. Forest Products Journal, Vol. 21, No. 3, p. 35.

Eckelman, C.A. and M.D. Hill, 1971. Textured vs. Plain Dowels - Which are Stronger? Journal Paper 4321. Furniture Design and Manufacturing, Vol. 43, No. 4, April, p. 60.

Eckelman, C.A., 1970. How to Design Strong Dowel Joints. Furniture Design and Manufacturing Vol. 42, No. 4, April, p. 54.

Eckelman, C.A., 1971. Designing Joints with Gusset Plates. Journal Paper 4534. Furniture Design and Manufacturing Vol. 43, No. 9, p. 72.

Eckelman, C.A., 1971. Shear Strength of Dowel Joints. Journal Paper 4567 Furniture Design and Manufacturing Vol. 43, No. 11, p. 52.

Eckelman, C.A., 1972. Shear and Bending Strength of Glued Corner Blocks. Journal Paper No. 4747. Furntirue Design and Manufacturing, Vol. 44, Nos. 6 and 7.

Hill, M.D., and C.A. Eckelman. 1973. Flexibility and Bending Strength of Mortise and Tenon Joints. Journal Paper No. 4758. Furniture Design & Manufacturing Vol. 45(1 & 2).

Eckelman, C.A. 1973. Holding strength of screws in wood and wood-base materials. Purdue Univ. Agr. Exp. Sta. Res. Bull. No. 895.

Eckelman, C.A. 1974. Torsional considerations in the design of furniture. Journal Paper No. 5794. Furniture Design and Manufacturing, Vol. 46, No. 3.

Eckelman, C.A., 1974. Working formulas for screws. Journal Paper No. 5459. Furniture Production, Vol. 37, Nos. 264, 265, 266.

Eckelman, C.A., 1974. Which Screw Holds Best. Journal Paper No. 5680 Furniture Design and Manufacturing, Vol. 46, No. 9.

Eckelman, C.A., 1975. Screw Holding Performance in Hardwoods and Particleboard. For. Prod. Journal Vol. 25 No. 6, p. 30. Journal Paper 5787.

Eckelman, C.A., 1974. Reasonable Design Stresses for Woods Used in Furniture. P.U. Agr. Exp. Sta. Bul. No. 916.

Eckelman, C.A., 1975. Effect of Holes on the Bending Strength of Wood and Particleboard Parts. P.U. Agr. Exp. Sta. Bul. No. 922.

Eckelman, C.A. 1975. Strength Design of Furniture.

1. Introduction, Furniture Methods and Materials; Jan., 1975.
2. Classification and Characteristics of Furniture Construction Systems, Furniture Methods and Materials; Feb., March, April, 1975.
3. Load Considerations in Furniture Design, Furniture Methods and Materials; June, July, August, 1975.
4. Simplified Methods of Furniture Analysis, Furniture Methods and Materials; Sept., Oct., Dec., 1975.
5. Design of Furniture Frame Members. Furniture Methods and Materials; Jan. and Feb., 1976.
6. Design of Furniture Joints. Furniture Methods and Materials; March, April, May, and June., 1976.

VENEER TIMBER QUALITY SURPLUSES IN THE TENNESSEE VALLEY

Monte R. Harold
Forest Products Specialist
Tennessee Valley Authority
Norris, Tennessee

INTRODUCTION

The Tennessee Valley Authority (TVA) was the first experiment in unified development of the total natural resources of a river valley, pioneering an idea that has spread around the world (Figure 1). TVA has built dams to regulate floodwaters, and the water held back by the dams has created a waterway for barge traffic and is used to generate electricity. TVA continues to work with states in promoting and encouraging wise management of all natural resources.

Over half of the Tennessee Valley is forested; 20.8 of the 36.6 million acres in the 125 Valley counties are commercial forest land. These forests supply raw materials for a billion dollar forest industry, the Valley's fourth largest, and provides more than 50,000 jobs with annual payrolls exceeding $260 million. The Division of Forestry, Fisheries, and Wildlife Development is responsible for TVA's forestry program which includes optimum watershed protection, forest and forest industry productivity, and environmental enhancement of the area. The program is a cooperative venture, with TVA joining state forestry and agricultural agencies to encourage reforestation, forest protection, productive timber and wildlife management, efficient wood utilization, and surface mine reclamation.

With over 80 percent of the forest land of the Valley in 356,000 private ownerships, TVA's forestry program must, of necessity, be an educational one. It is directed at both landowner and forest products industry segments. Forest development depends upon how they manage their forests and harvest the timber. The primary incentive for their cooperation is increased economic return from an improved resource.

FOREST RESOURCE AND INDUSTRY INVENTORIES

Since the early 1930's, TVA has inventoried the forest, noting timber volume, size, and quality by species in addition to growth and harvest trends. In the early sixties, a continuous forest inventory system was initiated in the Valley. The prime purpose of the system is to provide reliable, localized timber resource information for 64 county units that average about 300,000 acres of commerical forest.

The "TVA forest products industry" development program also keeps abreast of timber use trends, industry composition, market trends, and technological developments by collecting up-to-date information about the industry, the products, and the markets.

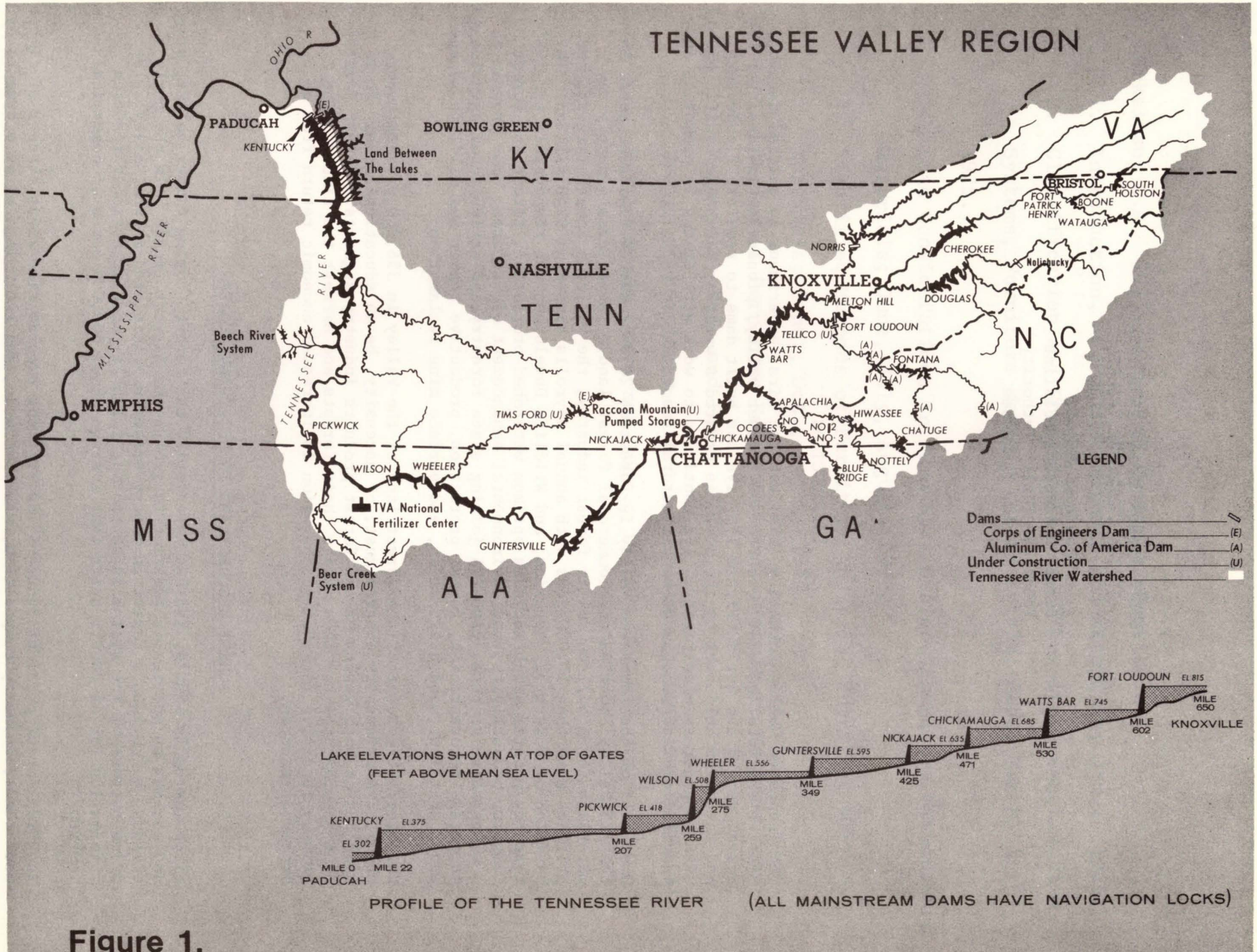

TENNESSEE VALLEY REGION
OHIO R
PADUCAH
KENTUCKY
(E)
BOWLING GREEN
KY
Land Between The Lakes
VA
BRISTOL
SOUTH HOLSTON
FORT PATRICK HENRY
BOONE
WATAUGA
NORRIS
CHEROKEE
Nolichucky
NASHVILLE
KNOXVILLE
MELTON HILL
DOUGLAS
TENN
MISSISSIPPI RIVER
TENNESSEE RIVER
Beech River System
TELLICO (U)
FORT LOUDOUN
WATTS BAR
(A)
FONTANA
N C
MEMPHIS
(E)
Raccoon Mountain(U) Pumped Storage
TIMS FORD (U)
APALACHIA
HIWASSEE
(A)
PICKWICK
NICKAJACK
OCOEES
NO 1
NO 2
NO 3
CHICKAMAUGA
CHATUGE
CHATTANOOGA
NOTTELY
BLUE RIDGE
WILSON
WHEELER
TVA National Fertilizer Center
MISS
GA
GUNTERSVILLE
Bear Creek System (U)
ALA
LEGEND
Dams
Corps of Engineers Dam (E)
Aluminum Co. of America Dam (A)
Under Construction (U)
Tennessee River Watershed
LAKE ELEVATIONS SHOWN AT TOP OF GATES
(FEET ABOVE MEAN SEA LEVEL)
KENTUCKY EL 375
EL 302
MILE 0
MILE 22
PADUCAH
PICKWICK EL 418
MILE 207
WILSON EL 508
MILE 259
WHEELER EL 556
MILE 275
GUNTERSVILLE EL 595
MILE 349
NICKAJACK EL 635
MILE 425
CHICKAMAUGA EL 685
MILE 471
WATTS BAR EL 745
MILE 530
FORT LOUDOUN EL 815
MILE 602
MILE 650
KNOXVILLE
PROFILE OF THE TENNESSEE RIVER
(ALL MAINSTREAM DAMS HAVE NAVIGATION LOCKS)

Figure 1.

This information helps point out opportunities for potential development on which TVA, community development groups, and industry can focus their efforts. Knowing how the forest resource has changed and is being used is the key to TVA's industry development program.

During the 1960's the average yearly Valley harvest of wood was 250 million cubic feet, less than one-third of the yearly growth. This storage of wood in the form of trees continues into the seventies. Analysis of Valley-wide timber resource data has identified three areas where present timber supplies, combined with available labor, electrical energy, and a suitable transportation system, warrants consideration by an industry requiring quality timber.

These three areas, all in the eastern portion of the Tennessee Valley are shown in Figure 2. All are located within the Appalachian region, which is expected to provide an increasing portion of the future hardwood timber supplies in the United States. The rising rate of forest land conversion to agricultural crops in the Delta hardwood region is the major reason for this shift. In the Valley region, the basic forest management practices of excluding fire and grazing have been in force for some 30 years. TVA inventories show not only a continuing increase in sawtimber volume per acre, but also an increasing volume of grade 1 and 2 trees. This trend is expected to continue until nearly full stocking is attained by the end of the century.

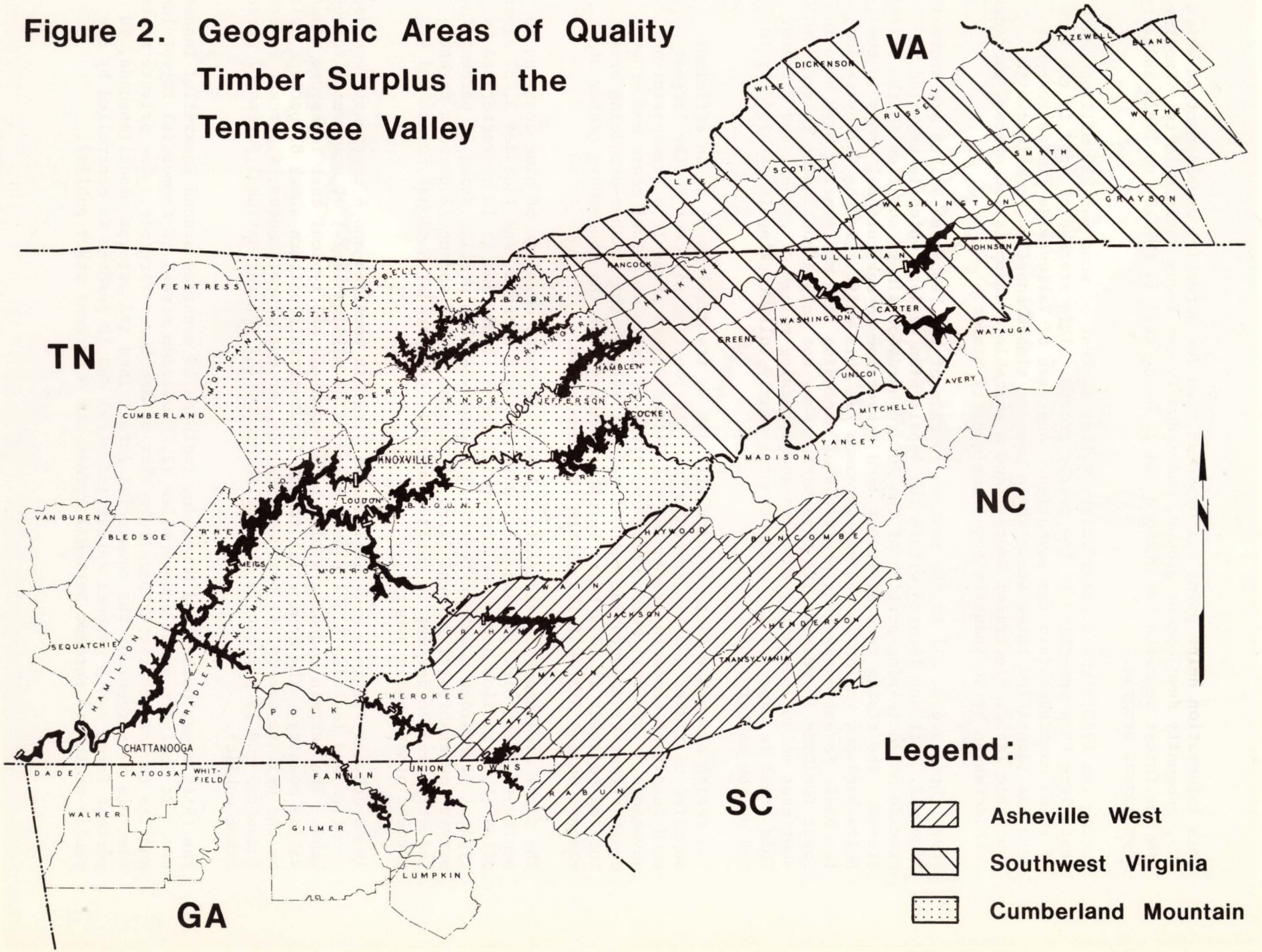
The region has other factors which will aid in its development as an efficient supplier of timber and timber products. Its location adjacent to the largest wood-furniture-producing region of the United States gives it a transportation advantage. This will become more important as increasing fuel costs and other costs affect transportation economics. Not only is this timber-producing area located adjacent to this major furniture market, but the geographic center of eastern United States falls within its boundaries.

The first area under consideration, Asheville West, consists of nine counties in southwest North Carolina and one county in north Georgia, and includes 3,027 square miles (1.94 million acres) of commercial forest land, and it is characterized by typical Blue Ridge mountain terrain. A landownership profile shows 64 percent in private ownership (21 percent farm, 41 percent miscellaneous, 2 percent forest industry) and 36 percent in public ownership (32 percent National Forest and 4 percent other public owners).

The Southwest Virginia area includes 11 Virginia counties and 8 northeast Tennessee counties and includes 4,521 square miles (2.89 million acres) of commercial forest land. The terrain contains a mixture of mountain and typical east Tennessee ridge-valley country. The commercial forest landownership pattern shows 81 percent held by the private sector (41 percent farm, 36 percent miscellaneous, 4 percent forest industry) and 19 percent in the public sector (17 percent National Forest, 2 percent other public).

The third area, Cumberland Mountain, includes 19 counties around Knoxville, Tennessee. It includes 4,367 square miles (2.79 million acres) of commercial forest land, and its terrain character parallels that of Southwest Virginia. The private sector controls 87 percent of the commercial forest land (42 percent miscellaneuous, 40 percent farm, and 5 percent forest industry) and 13 percent is controlled by the public sector (7 percent National Forest and 6 percent other public).

Figure 2. Geographic Areas of Quality Timber Surplus in the Tennessee Valley



TIMBER ANALYSIS

Timber Volume. There is considerable sawtimber[1] inventory within each of these areas. Table 1 shows that Southwest Virginia has the greatest volume of hardwood, with more than 6.6 billion board feet (International one-fourth of an inch log rule) of hardwoods followed by Asheville West and Cumberland Mountain with 6.4 and 6.3 billion feet, respectively. In large sawtimber, 15 inches DBH and larger, Asheville West leads with 4.2 billion board feet, followed by Southwest Virginia and Cumberland Mountain with 3.8 and 3.6 billion board feet, respectively. Cumberland Mountain ranks first in softwood volume, followed by Asheville West and Southwest Virginia.

TABLE 1. VOLUME OF SAWTIMBER ON COMMERCIAL FOREST LAND BY SELECTED SPECIES AND SIZE GROUPS IN SELECTED TENNESSEE VALLEY AREAS

Selected Area	Softwood	Hardwood	Hardwood 15 Inches DBH and Larger
	- - - - -billion board feet[1]- - - - -		
Asheville West	1.86	6.44	4.21
Southwest Virginia	1.15	6.59	3.77
Cumberland Mountain	2.48	6.26	3.58

1. International one-fourth inch log rule.

Source: Various TVA and USFS resource bulletins and special analyses.

While total volume is important, volume concentration is a better indicator of the economic availability of timber. By this measure, Asheville West, with over 3,300 board feet per acre, shows significantly more hardwoods than the other two areas as shown in Table 2. This volume per unit area advantage also holds true for hardwoods 15 inches DBH and larger. Asheville West, with 2,173 board feet per acre, averages about 900 board feet greater concentration of large sawtimber per average acre of commercial forest land than does the other two areas. The large ownership by the United States Forest Service in this area is significant and their administrative policies and constraints will determine the availability of this large sawtimber in the long run. There is little difference in unit volume between the other two areas, except that Cumberland Mountain has nearly twice as much softwood per acre than does Southwest Virginia.

1. Sound live hardwoods 11 inches DBH or longer and softwood 9 inches DBH or longer.

TABLE 2. AVERAGE VOLUME PER ACRE OF SAWTIMBER BY SELECTED SPECIES AND SIZE CLASS GROUPS IN THREE SELECTED TENNESSEE VALLEY AREAS

Selected Area	Softwood	Hardwood	Hardwood--15 Inches DBH and Larger
	Board Feet[1]		
Asheville West	960	3,326	2,173
Southwest Virginia	398	2,279	1,302
Cumberland Mountain	886	2,238	1,282

1. International one-fourth inch log rule.

Source: Various TVA and USFS resource bulletins and special analyses.

Timber Quality. The measure of timber quality is more elusive than timber volume. The application of quality measures between species, forest survey crews, and industry segments is also subject to error. Another confounding factor is that the grading system, for the most part, has been developed from old growth timber data and its applicability to the timber stands as they exist today is questionable. There is, however, because of log and tree grade structure, a relationship between size and quality. The volume by quality class distribution for Asheville West was determined by application of results from Blue Ridge region special log grade studies. While quality determination for Southwest Virginia and Cumberland Mountain was by tree grade by forest survey field crews.

There is no doubt Asheville West contains a greater proportion of quality timber than does the other areas. All selected species groups as shown in Figure 3 have in excess of 40 percent log grades one and two. In Southwest Virginia, only select red oaks and yellow-poplar exceed this timber quality determinate. In Cumberland Mountain only yellow-poplar approaches this 40 percent bench mark.

Net Annual Change. Volume and quality statements of timber inventory data alone generally do not yield sufficient information for sound resource development, industry procurement, or new and expanded industry decisions. Decision makers should think in terms of annual timber growth, removals, and net change of the timber base.

Annual net change of sawtimber for all species groups for all areas as shown in Table 3 shows large gains. This general information should be of interest to industry for it reflects a rather healthy timber resource situation. Of special interest in this analysis is the all hardwood species group. Southwest Virginia, the area with the smallest net annual change, is accumulating hardwood sawtimber at the rate of 96 million board feet per year. While Asheville West is increasing at 168 million board feet per year, Cumberland Mountain is banking timber at a 128 million board feet per year rate. The net change rate combines the standing inventory, growth rate, and use rate into a very important decision-making statistic.

FIGURE 3.

SAWTIMBER QUALITY DISTRIBUTION BY
SELECTED SPECIES GROUPS AND AREAS

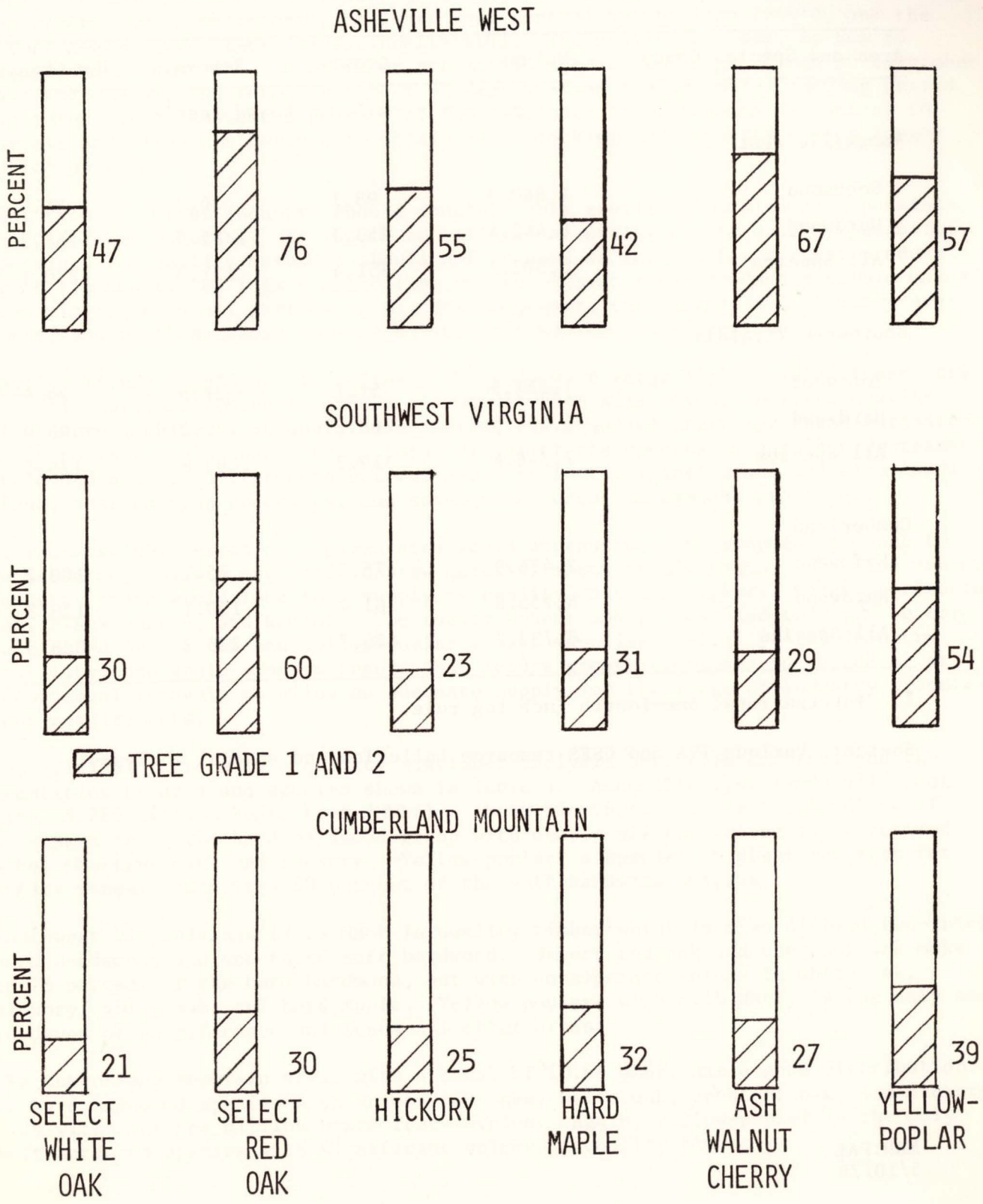


TABLE 3. VOLUME OF SAWTIMBER, NET ANNUAL GROWTH, ANNUAL REMOVALS, AND NET ANNUAL CHANGE ON COMMERCIAL FOREST LAND BY SELECTED TENNESSEE VALLEY AREAS AND SPECIES GROUPS

Area and Species Group	Volume	Growth	Removals	Net Change
	million board feet[1]			
Asheville West				
Softwood	1,860.3	98.1	36.3	61.8
Hardwood	6,442.4	253.3	85.0	168.3
All Species	8,302.7	351.4	121.3	230.1
Southwest Virginia				
Softwood	1,151.9	51.1	21.6	29.5
Hardwood	6,594.5	268.2	172.2	96.0
All Species	7,746.4	319.3	193.8	125.5
Cumberland				
Softwood	2,476.9	175.3	75.1	100.2
Hardwood	6,255.8	281.4	153.1	128.3
All Species	8,732.7	456.7	228.2	228.5

1. International one-fourth inch log rule.

Source: Various TVA and USFS resource bulletins and special analyses.

MRH:PAL
5/10/76

A major long range problem facing forest resource managers in the central and southern Appalachians is the large volume of timber expected to mature about the year 2,000. The forest industry, however, may look at this situation as an opportunity to meet projected increases in demand for wood products. Most of this land was brought under management, at least fire control by the late 1940's, and the forest regenerated itself exceptionally well. The challenge, then, is how to manage and harvest the timber in an attempt to spread the large volume of sawtimber that will mature one rotation (about 80 years) after the intensive cutting period. One method is to harvest a portion of the sawtimber as it becomes economical to harvest and allow the balance to obtain full stocking and maturity over a longer period of time.

What type of forest industry should consider this sawtimber surplus as a possible source of raw material? It should be utilized according to its quality potential. Certainly the quality material should not be used as furnish for a fiber product or as tie and timber logs. Allocation to the highest value product possible makes economic sense to all parties, i.e., the landowner, the logger, all industry segments, and to those whose responsibility is resource development.

Quality Timber Supplies. To estimate the supply of large high quality timber, the rate of sawtimber growth in excess of removal tree size class, and tree quality class were combined. As would be expected, the standard error for these estimates tends to increase as the percent total volume of the species or subclass decreases. Grade and quality differences between areas reflect original stand and site conditions, past cutting practices, and subsequent forest management practices.

An industry's interest in a given area would depend upon the proposed product to be marketed, the process, and the raw material input requirements. The face veneer industry today would look to a supply of quality oaks and hickory, never overlooking ash, black cherry, and walnut. The rotary veneer and plywood industry may be more interested in red oak and yellow-poplar timber supplies. Finally, for industry stability, one would want to insure that future growth continues to exceed or at least equal removals to allow an adequate supply for the range of industry procurement requirements.

The critical factors in a quality sawtimber analysis have been combined and the quantities by area and species shown in Table 4. Asheville West leads all areas with 15.285 million board feet (MMbf). About two-thirds of the total volume of this area is in the hard hardwood group with nearly all the volume in select red oaks, chestnut oak, and hickory. Yellow-poplar, a species of great interest for rotary veneer, comprises 80 percent of the soft hardwood surplus.

Southwest Virginia has 13.23 MMbf in quality timber which is also divided two-thirds hard hardwoods and one-third soft hardwood. Select red oak and chestnut oak make up 75 percent of the hard hardwood, but with considerate volume in white oak, hickory, white ash, and hard maple. Yellow-poplar, with 4.55 MMbf, is the only soft hardwood of significance and leads all other areas.

The Cumberland Mountain area, with a total of 10.66 MMbf, has a good distribution of hard hardwood species with select red oaks, white oak, chestnut oak, and hickory, each with over one million board feet surplus. Again, yellow-poplar is the only soft hardwood species with significant volume of quality timber.

TABLE 4. ANNUAL SURPLUS OF SAWTIMBER IN QUALITY[1] TREES 15-INCHES DBH AND LARGER BY SELECTED SPECIES IN SELECTED TENNESSEE VALLEY AREAS

Species	Areas		
	Asheville West	Southwest Virginia	Cumberland Mountains
	Thousand Board Feet[2]		
Selected Red Oaks	4,657	3,650	1,090
White Oak	0	840	1,480
Chestnut Oak	3,351	2,790	2,630
Hickory	2,312	960	1,710
White Ash	0	+[3]	290
Black Walnut	0	+	+
Hard Maple	370	+	310
Subtotal	10,690	8,630	7,700
Yellow-poplar	3,670	4,550	2,930
Black Cherry	+	+	+
Red Maple	796	0	0
Subtotal	4,595	4,600	2,960
All Selected Hardwood Species	15,285	13,230	10,660

1. Includes volume in tree grades 1 and half of grade 2.

2. International 1/4-inch log rule.

3. Less than 200,000 board feet surplus--included in species group total.

Source: Various TVA and USFS Resource Bulletins and special analyses.

CONCLUSIONS

All areas show there is ample timber available for expanded harvest of logs suitable for sliced or rotary-cut veneer. The timber could be purchased by existing veneer buyers and transported to veneer mills several hundred miles distant, then, perhaps, shipped back to adjacent furniture manufacturers. Or the timber supply may be interesting enough to draw new industry to one of these areas where labor and industrial sites are also available--the decision rests with industry.

MODERN METHODS OF PRODUCING FACE VENEER

by

Thomas F. Hale

To present a complete study of modern veneer manufacturing methods would require far more than the time (space) available to us here. Only the briefest mention can be given to subjects to which men have given lifetimes of study and development.

A little history is in order to provide a frame of reference. The basic order seems to work in a 40 year cycle. Up to 1900, quite crude methods were generally used. Timber, of course, was comparatively plentiful. The veneer saw was considered the optimum in quality veneer production. A few crude slicers and lathes had been built, but these had serious limitations in quality and productivity. Energy and pollution were not even considered as problems.

In 1900, the first Capital slicer was designed, and it was put into production in 1902. All basic elements of a modern slicer were incorporated in this machine. The mechanical dryer was introduced about 1910, replacing the old finger racks. Gradually, these machines were molded into the present general form, accompanied by parallel changes in logging and marketing. Mention cannot be made here of the development of modern plywood which has made today's products a reality.

By 1940 the technology was complete for the modern face veneer mill. This was first put together at the Stem mill in New Albany. This has been, to the present, the standard of most new mills, which differ actually only in detail. Although basically unchanged, this 1940 concept has permitted the incorporation of many features developed since World War II and has given all of us our foundation in modern veneer practices. It should also be noted that during this period the production of commercial veneers has become completely divorced from the face veneer industry, and has enjoyed a similar development of its own.

By 1980 changes in conditions will require that a different form must be fashioned. The market will require changes in the basic product being produced, within the limitations of the log supply available. Should a return to the older system of selling still used in Europe be considered? Should semi-dimension be the basic product? Will the market survive for high priced, carefully selected items, such as architectural veneers, pianos, office fixtures, and high grade furniture? How will this overall market affect flexibility of operation, and working capital requirements?

Let's look at the situation now developing. The basic problem of labor must be considered. How can the skilled men required for the operation be developed? How can the production labor force be stabilized within existing conditions of union activity and the lack of motivation of many job applicants?

Energy problems and pollution control will combine to modify existing practices a good deal. There is no doubt that much better use of power must be sought in every

department. Greater use of wood waste for efficient heat and saleable by-products such as chips, bark, mulch, and even use of scrap material for secondary purposes requires new appraisals.

These items will be greatly affected by government activities, to the point where a mill considered modern today possibly cannot be run even with massive capital expenditures. They will be controlling factors in the technology required.

Answers to these questions must determine whether face veneer will become just another commodity, cut from an indifferent to poor quality log supply by low grade, indifferent labor, into a product of no real character or appeal, or it will keep its charisma, if you will, as also a bit of an art, putting into the final product the qualities that have made fine hardwoods an essential part of our heritage. Those of us who have been brought up under the latter concept, and we may be a minority, feel that if the charisma dies, nothing of value will be left.

A brief study of some new European practices will be of interest. The equipment shown is in actual operation, in slightly different forms, in several plants in Europe. I have done some work along these lines in the U. S., but without reaching the point now attained by the Europeans.

MOVIE:

Several things attract our attention. The log yard shown is entirely enclosed. If sprinkled in accordance with American practice, end checking and staining are nearly eliminated and losses from potential problems such as pilferage and lawsuits by neighbors and itinerants are avoided. The dual headed debarker has two valid purposes. First, it gives a much better surface for final preparation at the cutting machine. Secondly, it removes most bark suitable for mulch, then, in finishing, provides an otherwise unusable fraction which is highly convertible into fuel. Collection problems remain to be solved, however, to get the most from this machine.

The sawmill is out of context here and should be carefully analyzed under another project.

Flitch preparation remains as a dirty, inefficient, dangerous part of our process. It is probable that use of hot water vats cannot be acceptable much longer from the standpoints of pollution, energy consumption, material handling, introduction of grit into the flitches or bolts, or liability for accidents. Steaming has been done with varying degrees of success in many hardwood rotary mills in the East. Sufficient information is not available, however, to make conversion entirely attractive at this time. However, it is my opinion that this will provide the greatest potential for improvement in present plants that I can visualize, as coupled with better debarking, it reduces other flitch preparation problems to a minimum.

The automated slicer operation shown here uses flitch preparation personnel as assistants to the cutter. Eliminating off-bearers and dryer feeders, it would seem to offer a tremendous advance in modern veneer mill technology. Made possible by the highly productive jet dryer, it may be the layout of the future. In the form shown, however, some points must be considered:

1. Flitch changing is no faster or more efficient than that practiced in our better mills in the 1940's, except for use of remote extension dogs.

2. European practice in knife and bar set-up is less critical than present U. S. standards. This reduces the time required in examining veneers, etc. and the degree of skill required by the cutter. It permits use of the knife holder

which, in turn, cuts down knife change time. It has some less desirable features, however. Much looser, rougher cutting is permissible in Europe. Further, it takes longer to build up acceptable pressure conditions and more sheets are lost in startup. This is balanced by less tendency to roll up, and makes handling through belts practical. Our tight cut domestic veneers would be quite a different thing to handle.

3. The operator's attention is diverted from cutting by the necessity of keeping the dryer conveyor properly filled. He will therefore be less quality conscious, particularly since he is unable to feel and examine the veneer being produced.

4. It is unlikely that the optimum speed of both dryer and slicer will be the same. Certainly the dryer will run empty during flitch changes, whetting, knife changes or unscheduled maintenance, with a complete loss of heat and fan power. When work breaks are added, this latter represents a very low efficiency in energy utilization.

5. Use of a fixed drying time can work well when woods having consistent drying characteristics are handled. When veneers having a wide range of moisture content, porosity, etc. are being cut, however, a much different problem exists. The drying curve must be levelled out to keep veneer within workable limits of final moisture content. This means a much longer, more expensive dryer, with even higher energy losses.

6. Solution or compromising of these and other factors will determine the final success or failure of this or any other future adaptations of the process of making veneer.

Another approach, if the cost of energy becomes intolerable, or the slicer and dryer cannot be run in direct tandem, is to arrange the dryer for end feeding. This gives an immediate savings of 35 to 40% in the heat requirement of the dryer. To realize the full benefit from this method, infeed and outfeed units must be installed. Since a dryer one-third smaller is required, the investment saved in this is available to pay for the handling equipment. No new technology is necessary for this method, since feeders have been used with rotary veneer for years.

Pollution control problems will affect the log yard, sawmill, and boiler room. As long as chips, mulch, etc. remain cheap, wood waste will be most attractive for fuel. If converted into steam it is, overall, only about 50 to 60% efficient at best, presenting problems with fly ash, unburned particles and, sometimes, odors. Hardwood, however, is much cleaner than softwood, lacking the resins and oils. So-called blue haze has not been a problem with hardwoods. Use of steam limits temperatures to about 270° F, whereas modern dryers do their best work about 400° F for shorter, more efficient machines, and minimum fan horsepower. Direct fired wood waste has been used in the Energex system on very large dryers with some good results, but the smaller machines, below 8,000,000 BTU per hour, have not proved to be adapted to this type of heat.

Dust and other scrap collection systems around both sawmills and veneer mills are generally poorly designed, requiring much manual labor to keep clean. No plant I know of is entirely free from this problem. One of the worst situations relates to bark. If the enclosed sprinkled yard is used, much improvement is to be expected.

One final item, generally overlooked, is the general appearance and atmosphere of the work areas. Unpleasant, damp, unsafe, poorly lighted and maintained mills have been partially the cause of difficulties in keeping the higher grade labor necessary for good work. A few of the newer mills have been very much aware of this need, and have received great benefits from attention to morale factors as well as working efficiency.

A few words are in order regarding the computer. Most of the mills now use it in some form. There is a great deal of room however, for expanding its usefulness. Input data direct from the production line may be used. This gives a potential for some immediate benefits. To name a few, we can obtain:

Inventory control with instant availability of data.
Practical means for logical analysis of log outputs, for purchasing decisions and quality control.
Quick, accurate cost figures, permitting actual costing of lots when they reach the sample room. This, in turn, gives immediate attention to problem areas and, equally important, to situations where unusual profitability occurs.
Market analysis will be possible to a degree not available to sales managers of the past.
Projections of trends will make it possible to make better decisions on purchasing, pricing, and long term projects.

It is highly likely, in fact, that the mills that survive will be those with the best programmed computers.

To sum up, the mill of the next few years will develop on well-defined lines, but will be severely limited by basic problems of log supply, market selectivity and government intervention. The technology is available for any purpose, but will, in all probability, be devoted to the following:

Cost and quality control.
Increasing the basic value of the product.
Reducing energy requirements and pollution.
Adjusting to the labor available.
Developing new ways of utilizing our materials, energy, and labor.

Only time will tell, however, what the nature of the business will be, or whether it will retain its position as a vital part of our man-made environment. It will depend on the effectiveness of every element in today's industry to provide the resources and the will to keep hardwood veneer products a vital part of the American scene.

MARKETING AS RELATED TO IMPORTED
AND DOMESTIC HARDWOOD VENEERS

By William A. Costoplos
V.P. Sales
The Dean Company

My subject today is "marketing" as related to imported and domestic hardwood veneers.

First of all, I wish to define my terms. Selling and marketing are not the same. A clerk in a drug store "sells" -- he puts the items a customer wants in a sack, adds the items up, and gives the customer his change. The butcher, the baker and the ice cream cone maker all do the same. They sell merchandise. (I'm afraid that's what alot of veneer salesmen in our industry do.)

But "marketing" -- that's something else! Part of marketing is selling -- but only part. Marketing implies much more. Especially in the veneer business. Most products (food, clothes, TVs, furniture and many others) are made and sold to a specific quality standard. Not veneers. When we cut a parcel of logs -- in any species -- we develop a "Duke's Mixture" of many grades -- a bit of architectural, door and stock panel, a modest percentage of "good furniture" grade -- a large percentage of medium, medium-low and low grade -- along with that inevitable bitter portion that is virtually unsaleable because of knots, splits, stain, buckle and those other natural and mechanical problems that plague the veneer maker.

You can "sell" the upper grades I have mentioned -- over the telephone -- no marketing required! But when you get down to the lower grades -- this is where we seperate the "sales clerks" from the "marketers"!! It is not enough to sell the upper grades -- and fill our warehouses with unsold lower grades. Unless we market and ship all grades -- we're in deep trouble. This dilemma is "elementary" ...as Sherlock Holmes would say. Like the time the horse fell into the well, they asked the boss what to do. He looked down and finally said: "Get him out!" Elementary!

So -- how do we get our horse out of the well? There is no easy answer. There are many knowledgeable men in this audience today. I would certainly not presume to "pontificate". There is no panacea. But I would like to put before you a few ideas -- a few suggestions -- as to what might be done to help us solve our problem -- which incidentally is also the problem of the furniture manufacturer -- and all others who use hardwood veneers in their products.

All of our hardwood raw material -- logs -- is not available to us and therefore, the veneer from these not available to you manufacturers -- because the omniscient U.S. Government (unlike our friends to the North and Latin America to the South, Africa and most other forward-looking countries around the world) allows any and all foreigners to come over here and cream our valuable natural resource -- hardwood logs. The principal beneficiaries of this folly are the log dealers and the foreign furniture and woodworking companies. When will the U.S. wake up? If, like other major countries, our Government would embargo the export of our raw

material -- the foreign companies would have to buy American-made veneer -- manufactured by American labor. The American manufacturer of furniture and wood products would have an equal shot at the total production. When Mr. Luther Hodges from this state of North Carolina was Secretary of Commerce, he effected such controls -- but when Secretary Weeks succeeded him, he immediately threw it out. So -- this would be one help. If everyone here keeps after his state and Washington legislators -- if the valuable timber resources of this country would be reserved for Americans -- and not foreigners -- it would mean more logs for the U. S. wood converters, a healthier, more viable and competitive price situation for raw materials; a higher average quality of veneers produced with a relatively lower percentage of low-end...It would give our customers an equal shot at the whole mix -- not just the "left-overs". This would help the veneer manufacturer solve his current frightening marketing problem.

Another real help would be for furniture makers and manufacturers of hardwood products to "walk that extra mile" to use grades other than "P&B" -- perfect and better -- which is what most customers are now demanding -- and nothing else. Trees just don't yield enough "P&B" grade. It used to be that furniture plants would buy lower grades for ends, drawer bottoms and would work around defects to get what they wanted. Now they import their drawer bottoms from the Orient -- or use hardboard or other materials. The cost of labor has moved up to where our customers won't fool with lower grade veneer so as to salvage what they need. There are some possibilities in this area for helping solve the veneer company's marketing problem.

Firstly, in isolated cases, certain thinking veneer users -- furniture manufacturers -- are buying both "P&B" and lower grades in the species they are using ...Walnut, Pecan, Oak, Cherry, whatever. They are finding places -- like drawer bottoms -- to use these lower grades -- even though their drawer bottoms cost a bit more -- at the same time, upgrading portions of the lower-grade veneers. Naturally this forward thinking customer is going to encounter less of a problem in getting the veneers he needs than will the inflexible buyer of "perfect and better" veneer only...because we, and other veneer producers, will literally "beat a path" to his door.

Secondly, thinking furniture manufacturers and veneer manufacturers are studying carefully the possibilities of "cut-to-length" and "palletized" veneers. This allows the veneer manufacturer an opportunity to take his slow-moving inventory and with his labor and equipment, furnish his furniture customer with exactly the grades and sizes he needs. This helps the veneer manufacturer to turn his entire inventory -- and increase his production (because his warehouses aren't bulging with slow-moving inventory). This technique will also make it possible for the furniture manufacturer to get a larger quantity of what he needs -- and the cut-to-size will furthermore save him freight and labor -- and will relieve his storage problem, too.

Thirdly, there is a need to acquaint all furniture manufacturers, designers, and retailers with the grades, other than "perfect and better" which develop in normal veneer production. Here again, certain astute furniture and plywood manufacturers have capitalized on "character-marked" veneers. The trend in furniture is to the natural -- the desired third dimension can only be achieved with genuine veneer -- not by prints, vinyls or laminates -- this is becoming more manifest with each passing day.

Fourthly, prior to World War II, the accepted standard thickness for veneers was 1/28". Oak was cut 1/26" and 1/24". Today, due to more efficient slicing, splicing, pressing, sanding, and finishing, the veneer users are accepting 1/28" Oak and slightly less thicknesses in other species. This has helped keep face veneer cost down, and to some degree, conserved our valuable supply of logs. I

do not, however, believe this is enough. The time is now for the industry to consider using veneers of 1/36" or perhaps somewhat thinner in order to maintain face veneer price stability and supply availability -- Conserve our resources and at the same time afford the veneer manufacturer a reasonable profit. With better cutting tchnology, underlayment and the advanced machinery available, I see no reason why a somewhat thinner standard thickness should not be established in the United States. This would be beneficial for the veneer manufacturer and the user alike.

At the Furniture Show, just concluded in High Point, alot of knotty Pine was shown -- this is certainly "character marked" in the ultimate. Also, alot of pecky Pecan was shown as well as knotty Oak, knotty Elm, pinknotty Cherry, gummy Cherry, wormy Maple -- and other types. The problem is, there are not enough character marked types being used -- and not nearly enough furniture manufacturers using these types, nor even studying the possibilities. The Fine Hardwoods-American Walnut Assn., in conjunction with the Hardwood Plywood Manufacturers Assn. are displaying the various character marked type veneers available at a showing to be held in High Point on May 11 and 12 at the Top of the Mart Building. This is certainly a worthwhile effort, and hopefully this will stimulate interest in the use of character marked types. Some years ago the Fine Hardwood Assn., prior to the mis-matched panel days, were confronted with the same problem of moving certain grades of various species of veneer. At that time they made a successful effort to promote "enchanted" Walnut and an abortive effort to promote the term "pixie" which would apply to all types of character marked veneers. It seems to me that if standard terminology could be arrived at to cover all of these miscellaneous character marked types, that such a name as "pixie Walnut", "pixie Pecan", "pixie Cherry", "pixie Oak", etc. would be a viable program and something for all of us to zero in on. These furniture pieces, for example, could carry actual labels stating "pixie Walnut", etc. The plan could be to publicize the concept of pixie "character-marked" veneers through advertising, publicity and labels. The concept would be that pixie veneers are genuine wood (often imitated but never duplicated) exactly as Mother Nature grew it. It would seem to be the most practical and viable way to promote character-marked veneers -- by concentrating on the promotion of a name for these veneers, such as pixie, with everyone in the industry backing up such a program. It would seem to be much better to do this rather than shhot our buckshot in all directions. Our limited resources for promoting character-marked veneers should be concentrated, in my opinion, on a program that would achieve the maximum impact for the limited dollars available.

I have tried to briefly outline the serious marketing problem that faces the veneer manufacturer today...the urgent necessity of not only selling the perfect and better grades, but of marketing all of the grades that develop -- and, in the true sense of marketing, for the veneer maker to know his actual current cost at all times, and to market the whole package with a fair return of profit. Quite a few veneer manufacturers, I believe, either do not know their current costs -- or completely ignore them. A few of them have gone out of business -- but others currently on the scene, make it very difficult for the veneer manufacturer who operates his business on a sound and businesslike basis and who plans to continue to serve the veneer users over the years to come, to generate a reasonable and legitimate profit. After all, a healthy veneer industry is vital to the wood product manufacturer.

I have pointed out two or three alternatives for promoting and marketing the slow-moving grades that constitute our industry's No. 1 Headache at this time. I have offered no magic remedy -- but hopefully, I have brought certain facts to your attention -- and perhaps have given you a few morsels of food for serious thought.

Thank you.